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USSR Space Life Sciences Digest

Issue 16

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USSR Space Life Sciences Digest: Issue 16 Reader Feedback Form

To our readers: We are working in a large number of highly technical, specialized areas for which adequate Russian-English glossaries have yet to be compiled. We ask your help in improving the accuracy and specificity of our English terminology. Please fill out the form below whenever you encounter an incomprehensible, incongruous, awkward or otherwise inappropriate term. While we solicit all suggestions for improved renderings, the statement that a term is inappropriate provides us with useful information, even when no better alternative can be suggested. A copy of this form will appear in all future issues of the Digest. Thank you for your help.

Abstract #	Incorrect or contextually inappropriate word or phrase:	Suggested rendering: ("??" is an acceptable entry)
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FROM THE EDITORS

Because we are still receiving requests for information on Digest subscription costs and eligibility criteria, we are repeating them here. NASA's USSR Space Life Sciences Digest is available without charge to anyone who requests it. To get on the mailing list, simply write to the address below.

Abstracts presenting or discussing space flight data in this issue:

Body Fluids: P743; Botany P728, P737; Cardiovascular and
Respiratory Systems P686; Developmental Biology P689;
Endocrinology P690, P733; Life Support Systems P731; Metabolism BR 12;
Musculoskeletal System P691; Psychology P726; Radiobiology P688.

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ADAPTATION

(See also: Hematology P741; Metabolism BRL2; Musculoskeletal System P696; Neurophysiology P720; Nutrition: P740)

PAPER:

P699(16/88)* Aydaraliyev AA, Maksimov AL, Chernook TB.
Capacity of polar personnel to adapt to high altitudes in the Antarctic.
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(6): 62-66; 1987.
[31 references; 3 in English]

Adaptation, High Altitudes, Antarctic, Polar Day and Night
Humans, Polar Personnel
Biological Rhythms, Functional State

Abstract: This study was performed at the "Vostok" station 3488 m above sea level during the 27th Soviet Antarctic expedition, which consisted of 17 people. Baseline data were obtained from examination of 14 individuals before posting to the Antarctic. Parameters reflecting functional state were measured at 7:00, 11:00, 15:00, 23:00, and 3:00 local time. These parameters, selected for ease of measurement, included: body temperature (measured orally), pulse, and concentrations of potassium and sodium in saliva. A model was used to derive information about biorhythms. Subject were divided into 2 groups on the basis of hypoxic tolerance (exact methodology not specified) as reflected in physical work capacity.

On day 30 of adaptation to high-altitude polar conditions, subjects with high tolerance of hypoxia maintained a 24-hour diurnal rhythm in body temperature, while those with low tolerance varied according to an ultradian (approximately 12 hour) rhythm. The acrophase in this latter group was shifted to 9.9 hours (compared to 19.8 hours in group 1). After 6 months of adaptation (in the middle of the polar night), differences in biorhythm were no longer evident in the two groups. However, both groups showed a different biorhythm pattern than they had during the baseline period. Analysis of pulse rate showed a significant portion of the variance was attributable to a 12-hour rhythm. The observed shift in acrophase from day to night indicated a significant discrepancy between cardiac function and typical activity peaks. Biorhythms in salivary sodium excretion during the polar night showed increased variability within the group and only a 12 - hour rhythm (baseline data demonstrated a 24-hour rhythm with a 12-hour component) and the acrophase displaced 1.7 to 2.6 hours). Potassium excretion also showed a 12-hour cycle.

The authors argue that biorhythm parameters may be used for predicting adaptivity. However, it should be noted that even hypoxia tolerant subjects show significant signs of stress during the middle of the polar night. When correlations among the various parameters were computed, it was found that the pattern during the polar night differed from baseline and that in general, number of significant correlations decreased. The authors conclude that under this set of conditions adaptation is not complete by the end of a 6-month period, even in subjects with high hypoxic tolerance.

Figure: Correlational clusters reflecting relationships between pulse, temperature, and salivary excretion of sodium and potassium in polar personnel at the "Vostok" station during the middle of the polar winter

BIOLOGICAL RHYTHMS: See Adaptation P699

BIONICS

MONOGRAPH:

M121(16/88) Seleznev VP, Selezneva NV.
Navigatsionnaya Bionika [**Navigational Bionics**].
Moscow: Mashinostroyeniye; 1987.
[255 pages; 100 figures; 54 references; none in English]

Key Words: Bionics, Mathematical Models, Spatial Orientation, Navigation, Man-Machine Systems, Perception, Neurophysiology, Insects

Annotation: This book covers the operating principles and theory of bionic sensors and transmitters of navigational information and complex navigational systems. It includes information about the scientific and methodological principles underlying bionics and systems approaches to the study of navigational properties of living organisms. It examines the operating principles, structures, mathematical models, and statistical and dynamic characteristics of scan and compare, inertial, and other bionic navigational subsystems. This book is intended for engineers working in the development of navigational instruments and subsystems.

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BIOSPHERICS

PAPER:

P619(16/88) Ivanov NR, Gasparyan SA, Guzeyev VV, Milovanova TN, Mishina NYa. **Cosmic and biospheric aspects of medical/ecological monitoring with regard to respiratory illnesses.**

In: Gazenko OG (editor).

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986].

Moscow: Nauka; 1986.

See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.

Pages: 60-61.

Biospherics, Atmospheric Factors, Solar Radiation
Humans, Patients, Cardiovascular and Respiratory Systems, Respiratory Disease
Public Health; Mathematical Modeling, Correlations

Abstract: The scientific/technological revolution has increased the social and economic need to optimize the population's living conditions. Public health cannot be improved without evaluating the combined effects of multiple natural and anthropogenic factors. It is no longer sufficient to base public health management on information about regional effects; "global" and "cosmic" parameters and data from aerospace, biospherics, and sanitary/hygienic monitoring must also be considered.

From the standpoint of studying the effects of cosmic factors on the biosphere, it is interesting to evaluate the significance of neutron components of cosmic rays (NCCR). Comparison of the number of children hospitalized with pneumonia and the intensity of NCCR (using data from the IZMIRAN /Institute of Terrestrial Magnetism, Ionosphere, and Radiowave Dispersion, USSR Academy of Sciences, for 1979-1981) revealed a negative correlation between these parameters. A negative correlation was also noted with deaths ($r = -0.48$, $p < 0.05$). Increase in the number of patients corresponded to increase in negative polarity of the interplanetary magnetic field (IMF), and decrease in patients to positive polarity. During the period of negative and unstable IMF polarity, the level of hospitalization was higher than mean values by a factor of 3-10. We noted a positive correlation between deaths from pneumonia and amplitude of pulsations of the geomagnetic field ($r = 0.36$) and field strength ($r = 0.39$, $p < 0.05$). When IMF polarity and geomagnetic storms were compared with rates of hospitalization and death, it was found that patterns in the clinical statistics corresponded to changes in heliogeophysical status.

Regression functions were derived and factor analysis applied to determine the interrelationships among multifactor environmental effects and multidimensional observed phenomena and to predict the resulting property. Our research, based on comparison of binary correlations obtained between 1960 and 1981, involved selection of factors having a close relationship with respiratory disease. We performed a regression analysis using the "Electron MK-56" programmable calculator. The quality of the statistical model was estimated on the basis of magnitude of the association among the

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resulting dependent and independent variables obtained using a multiple correlation coefficient (R), under the assumption that the closer R^2 was to 1, the more adequate the given regression equation for empirical observations. The most significant variables for predicting and preventing respiratory disease were the following:

I. Incidence of respiratory infection:

$Y_1 = 1400X_1 - 2160X_2 - 718000X_3 + 211000$, $R_1 = 0.98$ (X_1 - solar radio emission at frequency of 6100 MHz, X_2 - atmospheric pressure, X_3 - concentration of sulfur dioxide in the air)

$Y_2 = 3260X_1 - 5050X_2 + 22900X_3 + 4420000$, $R_2 = 0.90$ (X_1 - solar radio emission at frequency of 6100 MHz, X_2 - atmospheric pressure, X_3 - concentration of carbon monoxide in the air)

$Y_3 = 1420X_1 - 15700X_2 + 1.1X_3 - 8.9$, $R_3 = 0.90$ (X_1 - solar radio emission at frequency of 6100 MHz, X_2 - atmospheric pressure, X_3 - concentration of nitrogen peroxide in the air)

II. Hospitalization for bronchial pneumonia

$Y_1 = 22.4X_1 - 11.1X_2 - 0.001X_3 + 7810$, $R_1 = 0.80$ (X_1 - solar radio emission at frequency of 200 MHz, X_2 - temperature inversion; X_3 - incidence of autumn respiratory infections)

$Y_2 = 36.2X_1 - 14X_2 + 80.7X_3 + 7200$, $R_1 = 0.82$ (X_1 - solar radio emission at frequency of 200 MHz, X_2 - temperature differential between 1000 and 500 m, X_3 - concentration of carbon monoxide in the air)

III. Death rate from bronchial pneumonia

$Y_1 = 0.17X_1 + 0.46X_2 + 39X_3 - 132$, $R = 0.9882$ (X_1 - solar radio emission at frequency of 6100 MHz, X_2 - temperature differential between 1000 and 500 m, X_3 - concentration of dust in the air.)

Judging by the magnitude of the multiple correlations R (0.80 - 0.98), the expected reliability of the prediction of R^2 fluctuates between 64-98%.

BODY FLUIDS

(See also: Endocrinology P690; Gravitational Biology P718;
Neurophysiology: P721; Operational Medicine: P717)

PAPERS:

P687(16/88)* Kotovskaya AR, Baran'ski S, Gembitska D, Voytkovyak M, Vil'-Vil'yams IF, Kokova NI (USSR, Poland).

Increasing human tolerance of +G_z acceleration by increasing hydration level.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(6): 14-18; 1987.

[8 references; 4 in English]

Cardiovascular and Respiratory Systems, Tolerance, Acceleration, +G_z
Humans
Body Fluids, Hydration, Salt; Immersion

Abstract: A total of 62 individuals, aged 23-33, were exposed to +G_z acceleration on a centrifuge. Centrifugation was terminated when visual symptoms or their precursors occurred, or when cardiac rhythm was affected. Two experimental groups ingested a fluid supplement amounting to 7 ml (group 1) or 14 ml (group 2) water per kg body weight, while a third group were given a salt water supplement (group 3) consisting of 18 ml water and 0.15 g sodium chloride divided into 3-4 portions taken with a meal; a control group received no supplement. The water supplement was ingested under normal conditions 30 minutes before centrifugation, while the salt water supplement was administered in different doses during a 7-day period of dry immersion 16 hours before exposure to acceleration. Electrocardiograms were recorded in order to identify disruptions of cardiac rhythms. Stroke and minute circulatory volume were measured using impedance plethysmography. Systolic, diastolic and pulsed blood pressure were measured in the vessels of the arm and a cardiovascular stress index was computed ($\Delta \text{heart rate} - \Delta \text{BP}_s + \Delta \text{BP}_d$). In addition, level of blood electrolytes, total protein, and hematocrit were measured, and fluid retention recorded.

Water and salt water supplements had positive effects on acceleration tolerance. Endurance limit increased by 0.3 units over baseline for group 1, and 0.8 units (statistically significant) for group 2. Endurance limit of group 3 was 0.5 units above that of a group which had undergone a similar period of immersion without the supplement. Response of the cardiovascular system to acceleration was less pronounced after both water and salt water loading. Heart rate increase was 4.1, 8.4, and 9% less than control value in groups 1, 2, and 3, respectively. Stroke volume of blood showed greater stability after centrifugation in group 3 than in the comparable control group, while minute volume was 22% higher, with systolic ejection stable. Fewer instances of heart rhythm disruption occurred after the salt water supplement. This supplement was also found to decrease stress arising from acceleration after immersion, as indicated by value of the stress index. After immersion, diastolic blood pressure increased in response to centrifugation only in subjects receiving the supplement. The beneficial effect of fluid loading evidently results from an increase in circulating blood volume, as indicated by decreased electrolyte concentration and hematocrit, and relative increase in plasma volume in

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groups 2 and 3, while plasma volume decreased by 4% in control subjects. Increased hydration persisted for about 40 minutes, after water loading, and up to 8 hours after salt water loading. Effects of increasing hydration appear to be a direct function of amount of fluid loading and retention. This explains the increased effects in group 2 compared to group 1, and also the fact that in group 3 there was a high negative correlation between degree of fluid retention and decreased acceleration tolerance after immersion. This suggests the use of antidiuretic hormones in conjunction with fluid loading. The authors conclude that fluid loading alone might be sufficient to enhance acceleration tolerance in aircraft crews; however, long-term saturation of the body with fluid and electrolytes are recommended for use by cosmonauts before reentry.

Table 1: Changes in cardiovascular parameters after exposure to $+3G_z$ acceleration after immersion with and without fluid-electrolyte loading

Table 2: Changes in biochemical parameters of the blood before centrifugation and fluid loading and after centrifugation

Figure 1: Increased maximum tolerance for $+G_z$ acceleration as a result of fluid loading under normal conditions and after simulated weightlessness

Figure 2: Individual decrease in tolerance for $+G$ acceleration after simulated weightlessness as a function of fluid retention after fluid electrolyte loading.

BODY FLUIDS

P743 (16/88) Noskov VB, Afonin BV, Levedev VI, Boyko PA, Sukhanov YuV, Kravchenko VV, Kvetyanski R (Czech).

Fluid-electrolyte metabolism and its hormonal regulation under conditions of long-term space flight.

In: Gazenko OG (editor).

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986].

Moscow: Nauka; 1986.

See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.

Pages: 354-355.

Body Fluids, Metabolism, Fluid-Electrolyte; Endocrinology, Hormonal Regulation, Adrenal Gland, Corticosteroids
Humans, Cosmonauts
Space Flight, Salyut-7, 237-day Flight

Abstract: A number of investigations focusing on the adaptive restructuring of various systems and physiological functions in humans during long-term exposure to weightlessness were performed during the 237-day flight on Salyut-7.

In the "Metabolism-K" experiment two cosmonauts, with the aid of a physician, collected urine and recorded consumption of water and food for three consecutive days (days 216-219 of flight). Every day aliquots of urine were sampled and frozen. On day 2 of the experiment venous blood was taken and plasma samples centrifuged and frozen. Biological samples and food products were analyzed in the laboratory.

Decrease in daily renal excretion of sodium, chlorine and magnesium was discovered in one cosmonaut. An increase in potassium in the urine and excretion of osmotically active substances was found in the other. At the same time the percent of renal excretion of sodium decreased with respect to its consumption in both crewmembers. Concentrations of calcium, magnesium, and phosphorus in capillary blood from the finger on days 116 and 222 of flight were within normal limits and did not differ from baseline values. After standard calcium loading, the concentration of calcium did not occur; concentration of magnesium and phosphorus in the blood was unchanged, indicating the reactional specificity of this test was maintained.

Changes in fluid-electrolyte metabolism were accompanied by restructuring in the system of hormonal regulation of homeostasis. Cumulative excretion of aldosterone increased in one cosmonaut and decreased in the others and was correlated with varying levels of appetite for salt. Renal excretion of aldosterone-18-glucuronide increased in both cosmonauts, indicating stress on the mineral corticoid function of the adrenal gland, as a consequence of which renal excretion of sodium decreased. At the same time excretion of aldosterone precursors -- 11-deoxycorticosterone and especially the glucuronide fractions -- decreased, probably as a result of their mobilization for synthesis of mineral corticoids. Concentration of renin in blood plasma increased. There was a concurrent substantial increase in renal excretion of antidiuretic hormone, ensuring adequate fluid retention. We also observed signs of modification of steroidogenesis and metabolism of steroid hormones: concentration of estrogens in blood plasma increased,

BODY FLUIDS

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probably due to other corticosteroids.

Thus, in spite of individual differences, a 216-219 day space flight was associated with positive balance of fluid and sodium and activation of hormonal systems controlling fluid-electrolyte homeostasis. In addition, we found indications of changes in steroidogenesis and metabolism of steroid hormones, and also modification of the corticosteroid secreting activity of the adrenal gland.

BOTANY

(See also: Radiobiology: P688)

PAPERS:

P728(16/88) Abilov ZK, Aliyev AA, Novruzova ZA, Mashinskiy AL, Ragimova GK, Alekperov UK, Fadeyeva SN.

Functional, morphological and anatomical changes in sprouts of orchids cultivated during a 110-day space flight.

In: Gazenko OG (editor).

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**].

Moscow: Nauka; 1986.

See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.

Pages: 263

Botany, Functional, Morphological and Anatomical Changes
Orchids
Space Flight, 110-day, Salyut-7

Abstract: A comparative analysis was performed on orchids grown during a 110-day space flight on Salyut-7 and a control group grown in the laboratory. Parameters studied included: leaf cell ultrastructure; fluorescence spectra; absorption and its primary products in leaves and leaf homogenates; concentrations of chlorophyll and ATP in leaves; and a anatomical/morphological analysis of root structural elements. The greatest structural changes among the organelles of the palisade parenchyma of leaf mesophylls occurred in the chloroplasts, which underwent morphological modifications of the grana-thylakoid membrane system, while concentration of carbohydrates decreased. There was a displacement in the primary maximum in low-temperature fluorescence spectra, which, evidently, occurred due to the predominance of long-wave aggregated forms of chlorophyll. In contrast to the control group, flight orchids showed significant stimulation of chlorophyll synthesis, but no changes in composition. Total concentration of ATP did not alter significantly. There were significant quantitative differences in the structural elements of the roots of four species of control and experiment orchids, demonstrating that the effects were species-specific in nature.

P737(16/88) Sychev VN, Galkina TB.

Investigation of the developmental dynamics of a Chlorella population and its age structure after exposure to weightlessness.

In: Gazenko OG (editor).

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**].

Moscow: Nauka; 1986.

See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.

Pages: 297-299.

Botany, Microbiology, Population Dynamics, Age Structure
Chlorella
Space Flight, Salyut-6, Short-term

Abstract: In a series of experiments we studied the age structure of populations of Chlorella which had been exposed to weightlessness on Salyut-6 in an active state. The algae were brought on board in an inactive state, were planted in a nutrient medium by the cosmonauts, and were grown under heterotrophic conditions in hermetically sealed IFS-2 containers. Six experiments were conducted, with duration of exposure to weightlessness ranging from 4-18 days. We studied the dynamics of population development and the ratio of individuals belonging to various age groups within the population during postflight cultivation and heterotrophic and autotrophic conditions under a variety of environmental stresses.

The dynamics of increase in the number of algae cells were describable by the usual s-shaped curve and completely corresponded to the control curve. The duration and nature of all developmental phases of flight and control populations were the same, independent of subsequent growth conditions. This suggests that all processes underlying regulation of population dynamics underwent no change after exposure of the algae to weightlessness.

The experiments enabled us to study the dynamics of the age structure of populations of cultures developed from individuals sprouted in space. Each experiment began with a low density suspension and, for this reason, the population's age structure formed during a period of increasing suspension density. For inoculation we used a suspension with a small concentration of mother cells. This meant that during the first two days the culture was synchronic (on day 1 mother cells predominated; on day 2 autospores). Only after two days did the population develop the age structure characteristic of algae, after which the distribution of cells on the basis of physiological age fluctuated around this "typical" distribution. No differences in age structure dynamics were associated with duration of preliminary exposure to weightlessness.

The age structure of the Chlorella population sprouted in weightlessness was a function of growing conditions during the cultivation period. No differences were found between flight and control cultures in any series of experiments. Photosynthetically active individuals dominated, which is characteristic of young, fast-growing populations of organisms. The relative number of individuals in this group fluctuated, ranging under heterotrophic conditions from 59-60%, and under autotrophic between 66 and

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69% of the total number of individuals.

Mother cells and autospores are the most labile groups in the population. Their relative numbers may fluctuate because of shifts in the division period associated with the effects of adverse environmental factors (retarding division) or extreme factors (frequently stimulating division). The relative number of mother cells was the same in populations of flight and control cultures (based on mean data obtained during the experiment), and the maximal difference between them did not exceed 15%. Between the individual series of experiments fluctuation in the proportion of these individuals was greater (50%), which was associated with differing growth rates in algae grown under various conditions. The relative number of autospores in algae populations within a single experiment was the same for the flight and control groups. Fluctuations between the experiments were significant, the greatest differences in the number of autospores in populations were obtained between various types of postflight growing conditions, which, as in the case of mother cells, evidently, was associated with different algae growth rates as a function of growth conditions.

Thus, our analysis of population age structure demonstrated that all the basic biological characteristics of individuals in ontogenesis (time to generate individuals, number of autospores forming, time ratios of developmental phase of individuals) in Chlorella grown on the ground after exposure to weightlessness were normal; observed fluctuations did not exceed acceptable limits.

CARDIOVASCULAR AND RESPIRATORY SYSTEMS

(See also: Biospherics P619; Body Fluids P687; Man-Machine M120; Operational Medicine P717; Reproductive Biology P724)

PAPERS:

P686(16/88)* Romanov YeM, Artamonova NP, Golubchikova ZA, Zavadovskiy AF, Korotayev MM, Lyamin, VR, Turbasov VD.

Results of longitudinal electrocardiographic observation of cosmonauts.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(6): 10-14; 1987.

[14 references; 3 in English]

Cardiovascular and Respiratory Systems, Electrocardiograms
Humans, Cosmonauts, Longitudinal Study
Spaceflight, Long- and Short-term Flights, Multiple Flights

Abstract: EKGs were recorded and analyzed in 21 cosmonauts participating in 42 flights from 1964 to 1985. Of these, 1 was followed medically for 5 years or less, 5 for 6 to 10 years, 5 for 11 to 15 years, and 10 for 16 to 20 years. Seven subjects each had participated in 1, 2, and 3 flights. EKGs (using the traditional and D-S leads) were recorded pre-, in- and postflight, with subjects at rest and participating in provocative tests (postural, LBNP, and graded physical exercise on a bicycle ergometer). In addition EKGs were monitored during launch, EVAs, and reentry, and when tasks requiring exertion were performed. The number of pre- and postflight EKGs recorded varied as a function of duration of training and readaptation periods, but during long-term flights EKGs were recorded once every 2-3 weeks.

Results showed that three cosmonauts had completely normal EKGs throughout the observation period. All these cosmonauts had participated in short-term flights only, two had flown once and one twice. EKGs of the other 18 cosmonauts showed some deviation, in addition to tachycardia at launch, injection into orbit, and recovery, which was common to all subjects. These deviations are described in the table. The most common symptom was extrasystole, which occurred 39 times in 13 cosmonauts. During months 2-3 of long-term flights 11 cosmonauts showed decreased R and S wave amplitudes, which gradually decreased during the recovery period. All 3 cosmonauts participating in long flights showed diffuse decrease in T wave amplitude, which was uncommon in short-term flights. The authors state that such bioelectric changes in cardiac activity can be explained by restructuring of reflexes, and changes in fluid-electrolyte metabolism and microcirculation. Recovery of EKG parameters occurred in 1-2 weeks after short-term flights, but took 1-2.5 months after long-term ones. During the long-term postflight recovery period, 3 cosmonauts developed cardiac pathology, myocardial infarction in one case, and high blood pressure in two, in one case accompanied by latent ischemic disease. These symptoms are not believed to be associated with previous space flight.

The authors conclude that the EKG changes cosmonauts developed in connection with space flight were functional in nature and disappeared when the conditions causing them were terminated. The occasional development of extrasystole in the majority of subjects is thought to be associated by situational emotional and/or physical stress. Comparison of these results

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with data on American astronauts confirmed the frequency of extrasystole. The American finding of functional disturbances in the atrioventricular system was not reproduced in the Soviet cosmonauts.

Table: EKG changes in cosmonauts pre-, in-, and postflight. Number of observations (1 = at rest; 2 = during provocative tests; 3 = at rest, while performing motor tasks and during EVAs)

EKG Changes	Preflight		Inflight		Postflight	
	1	2	3	2	1	2
Rhythm disturbances:						
Sinusoidal bradycardia (< 40 bpm)	1	—	1	—	1	—
Sinusoidal arrhythmia (Δ HR > 25 bpm)	2	—	2	—	2	—
Migration of rhythm source to atrium	—	1	—	—	2	—
Extrasystole	2	14	8	1	2	12
Increase in duration:						
Atrioventricular conduction (P-Q interval > 0.20 sec)	1	—	—	—	—	—
Intraventricular conduction (QRS complex > 0.10 sec.)	1	—	1	—	—	—
Incomplete right bundle-branch block	1	1	1	1	1	1
Change in the de- and repolarization phases:						
Decrease in QRS amplitude	—	—	11	—	11	—
Decrease and flattening of T wave	—	—	14	—	18	—
Deformation of T wave	—	5	2	—	1	—
Horizontal depression of S-T segment to 0.2 MV	—	—	—	—	1	2
Increase in electric activity:						
Right ventricle	—	—	—	—	2	—
Left ventricle	—	—	—	—	2	—

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P695(16/88)* Kayfadzhyan MA, Tikunov BA.

The effects of cardioactive compounds on myocardial actomyosin in rats undergoing acceleration.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(6): 47-49; 1987.

[16 references; 8 in English]

Cardiovascular and Respiratory Systems, Myocardial Actomyosin
Rats

Acceleration, $+G_x$, Cardioactive Compounds

Abstract: This study tested the hypothesis that when physical stress on the heart is increased, the modulating effect of cardioactive compounds on the actomyosin complex becomes similar to that of Ca ions. Experiments were performed on a total of 90 male white rats divided into 3 groups. Group 1 was a vivarium control. Groups 2 and 3 were periodically strapped into a centrifuge such that centrifugal force operated in the head-torso direction. The animals were exposed to acceleration of $+5-G_x$ for 15 days. Exposure lasted 5 minutes on day 1, with duration increasing by 5 minutes on each of the next 5 days, reaching 30 minutes by day 6. Animals in group 2 were sacrificed and studied on day 2 after termination of centrifugation, while rats in group 3 were studied 2 months after treatment termination. Native actomyosin was obtained from the left myocardial ventricle, and desensitized actomyosin from a native actomyosin suspension. Purity of these protein preparations was confirmed. Reactions of superprecipitation and ATPase actomyosin were studied in a medium containing 20 mM tris-HCl, 0.15 M KCl, 0.025 mM MgCl₂, 0.25 mM ATP, 0.25 mg/ml protein, 4mM DTT. Effects of Ca²⁺ were excluded by adding 1 mM EGTA to the incubation medium.

Adrenalin in concentrations of 10⁻⁹-10⁻⁶ M activated rate of superprecipitation and ATPase reactions to native actomyosin in the control group, with the greatest activating effect occurring with adrenalin concentration of 10⁻⁸ M. After exposure to acceleration, these reactions slowed by approximately 50% at this concentration. In addition, the Ca²⁺ reactivity of native actomyosin preparations decreased. Two months after exposure to acceleration, there was a tendency for the parameters studied to return to their baseline values. When the beta-blocker obzidan [1-1-Isopropylamino-3(1-naphthoxy)anol hydrochloride] was administered, the pattern of reactions changed. The kinetic curves describing the relation between reaction rates and concentration were bell- rather than s-shaped. Although the maximum activating effect under control conditions occurred at 10⁻⁸, when rats were exposed to acceleration, maximum responses occurred at 10⁻⁷ and 10⁻⁶ M for superprecipitation and ATPase reactions, respectively. After 2 months, these parameters had not returned to their baseline values. Adrenalin and obzidan did not affect the magnitude of Mg²⁺ATPase desensitized actomyosin because of the absence of a Ca²⁺ binding component of the troponin-tropomyosin complex. Nor did Ca ions affect this reaction.

These results are interpreted as confirming the hypothesis that after increased physical stress on the heart, the modulating effects of cardioactive compounds on the actomyosin complex show a pattern of changes similar to the effects of Ca ions. The decrease in reactivity to cardioactive substances after acceleration is concluded to be associated with regulatory protein components of the native actomyosin which mediate the modulatory effects of these compounds. The remainder of the differences in

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reactivity of actomyosin to cardioactive compounds, which persist for as long as two months, are attributed to incomplete recovery of the properties of regulatory proteins.

Figure 1: Changes in rate of superprecipitation and Mg^{2+} -ATPase of myocardial native actomyosin in the control, acceleration, and recovery groups in the presence of various concentrations of adrenalin in the medium

Figure 2: Changes in rate of superprecipitation and Mg^{2+} -ATPase of myocardial native actomyosin in the control, acceleration, and recovery groups in the presence of various concentrations of obzidan in the medium

Figure 3: Changes in Mg^{2+} -ATPase of desensitized myocardial actomyosin in control animals in the presence of various concentrations of adrenalin and obzidan

CARDIOVASCULAR AND RESPIRATORY SYSTEMS

P697(16/88)* Yarullin KhKh, Vasil'yeva TD, Neumyvakin IP.

Effect of exogenous contrapulsation synchronized with heart rhythm on regional and central hemodynamics in humans.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(6):54-58; 1987.

[16 references; 6 in English]

Cardiovascular and Respiratory Systems, Hemodynamics, Central and Regional Humans, Males

Exogenous Contrapulsation

Abstract: This work studied the effects of exogenous contrapulsation [defined as creation of positive pressure on the soft tissues of the limbs increasing in a wave from the periphery to the center and synchronized with the heart] on hemodynamics of subjects at rest or in a tilt test in order to explore the possibilities of using this technique in the early period of readaptation after space flight or its simulations. Subjects were 20 healthy male volunteers. In the first experiment, 1.5-2 hours after breakfast subjects, while prone, were fitted with cuffs (3 on the lower and 2 on the upper limbs) which were inflated to create a pressure of 60 and 90 mm Hg during the diastolic phase of heartbeat. During this treatment, bipolar impedance plethysmography of the head was performed using mastoid leads. In the second experiment, subjects were placed in passive upright position (70°) on a tilt table, for 5 minutes without exogenous contrapulsation and 5 minutes with it. Pressure schedules were determined separately for each individual while he was in a horizontal position. Parameters measured to reflect adequacy of the contrapulsation treatment were: absence of a venous wave on the encephalic plethysmogram, diastolic index increased by no more than 100% and absence of sensations of discomfort. Additional parameters measured included stroke and minute volume of blood flow (determined from a tetrapolar impedance plethysmogram of the lung and trunk), and blood pressure. Systolic volume was derived using a formula.

In horizontal position with contrapulsation pressure at 60 mm Hg, pulsed blood perfusion increased in the brain, especially in the system of the vertebral and basillary arteries. Increasing contrapulsation pressure to 90 mm Hg intensified this effect. A parameter reflecting tonus of large arteries increased in the cerebrum in response to contrapulsation with no differences between the two pressure levels. Tonus did not increase significantly in the vertebrobasillary system. Virtually no change occurred in the tonus of arterioles, veins and venous outflow in the cerebrum, but these parameters increased substantially in the vertebrobasillary system. During the tilt test without contrapulsation, heart rate increased by 10 beats per minute, stroke circulatory volume decreased by 30%, and minute volume by 20%. Pulsed blood perfusion decreased in the cerebrum, especially in the vertebral and basillary arteries, and lungs, as did all tonus parameters. When pulsed contrapulsation was introduced during the tilt test, shifts in central and peripheral hemodynamics decreased significantly. Changes in tonus and cardiac parameters also diminished. All subjects reported decreases in discomfort when contrapulsation was introduced. Endogenous contrapulsation is recommended as a simple, reliable, and nontraumatic method for increasing blood supply to vital organs (especially the brain) and may be useful for counteracting orthostatic hypotonia.

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Figure 1: Changes in pulsed blood perfusion and tonus of arterioles and veins during exposure to various schedules of exogenous contrapulsation while in a horizontal position

Figure 2: Changes in pulsed blood perfusion and tonus of arterioles and veins during a passive tilt test with and without exogenous contrapulsation

Figure 3: Regional impedance plethysmograms of subject S. during a tilt test with and without exogenous contrapulsation

CARDIOVASCULAR AND RESPIRATORY SYSTEMS

P698(16/88)* Breslav IS, Isayev GG, Rymzhanov KS.

The effect of oxygen inhalation on the respiratory function during exercise and additional resistance to respiration.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(6):59-62; 1987.

[21 references; 9 in English]

Cardiovascular and Respiratory System, Respiratory Function

Humans, Males

Oxygen Inhalation, Physical Exercise, Resistance to Respiration

Abstract: Research was performed on 4 healthy males aged 25 to 35. Respiratory parameters were recorded using a spirographic device. Dynamics of inspiratory activity of the respiratory center were assessed on the basis of maximum rate of growth of inspiratory pressure in the respiratory tracts at the beginning of inhalation, measured with a pressure transformer attached under the face mask. In addition, pCO_2 of alveolar gas was recorded on a mass-spectrometer, which was also used to determine gas exchange. Heart rate was also measured. Subjects performed work on a bicycle ergometer until minute respiratory volume reached approximately 30 l. Work performed ranged from 60-100 W. The entire session lasted 2.5 hours. Alternating work and rest periods lasted 10 minutes and 7.5 minutes each, respectively. Respiratory resistance, inspiratory, expiratory, or both (20 cm $H_2O \cdot l \cdot sec.$) was created using a perforated diaphragm placed in the appropriate respiratory channel. Data from free breathing was used as a control. Some trials used air and others inhalation of pure oxygen. Conditions were presented in randomized order.

At rest increased respiratory resistance did not lead to noticeable changes in respiratory parameters when either air or oxygen was breathed. However, this factor did have a substantial effect during exercise. Increased ventilation occasioned by physical exertion was lower than during free breathing. This was particularly evident during inspiratory-expiratory resistance and least marked for expiratory resistance. Breathing oxygen noticeably enhanced this hypoventilatory shift. Least ventilatory increase occurred in response to hyperoxia with both inspiratory and expiratory resistance. As a result of the attenuation of the ventilatory reaction, pCO_2 of alveolar gas increased during exercise. For both media, the effect was least pronounced when resistance was inspiratory. Across the 7 exercise periods pulmonary ventilation remained rather stable, and only dropped when there was both inspiratory and expiratory resistance. At the same time, hypercapnia in air and in oxygen increased gradually from period to period. In some subjects breathing oxygen, alveolar CO_2 with inspirato-expiratory resistance reached 66-68 mm Hg. This was not associated with any changes in overall gas exchange, since oxygen consumption and CO_2 expiration remained relatively constant during exercise in all experimental conditions. Compensatory reaction on the part of the respiratory regulatory system was manifested in an increase in the parameter reflecting central inspiratory activity. When subjects breathed air during exercise combined with inspiratory-expiratory resistance this parameter increased by a factor of 5 compared to exercise with no resistance. When subjects were breathing oxygen this parameter increased only by a factor of 3. Thus oxygen attenuated the reaction of the respiratory system to combined exertion and respiratory resistance. This response is mediated by the chemoreceptors of the carotid body. In addition, the present data show that cardiovascular

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responses to respiratory resistance are also attenuated by breathing oxygen. The authors conclude that for any individual exposed to a combination of physical exertion and impeded respiration, there is an optimal level (from the standpoint of respiratory function) of oxygen in the breathing medium. Increases in pO_2 over this optimal level lead to deterioration of respiratory function.

Figure 1: Pulmonary ventilation under conditions of breathing air and oxygen at rest and during physical exertion

Figure 2: The effects of additional respiratory resistance on dynamics of pulmonary respiration and alveolar pCO_2 during physical exertion

CARDIOVASCULAR AND RESPIRATORY SYSTEMS

P703(16/88)* Nekhayev AS, Vlasov VD, Stepanov VK, Andriyenko YuI.

The effect of a hypercapnic-hypoxic test on the cardiorespiratory parameters of individuals with neurocirculatory dystonia.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(6): 83-86; 1987.

[12 references; 1 in English]

Cardiovascular and Respiratory Systems, Cardiovascular Parameters
Humans, Pilots, Patients, Neurocirculatory Dystonia
Hypercapnic-Hyperoxic Test

Abstract: Subjects in this experiment were 20 healthy (group 2) pilots and 12 patients in the same profession suffering from hypertonic neurocirculatory dystonia (group 1). Subjects were required to rebreath [inhale part or all of the gases previously exhaled] and heart rate, respiratory rate, minute respiratory volume, mean maximal inhalation rate for 1 minute, and effective respiratory period for 1 minute were measured. In addition, tetrapolar impedance plethysmography was used to determine stroke and minute blood volume and total peripheral resistance was derived. Blood pressure was also measured and rhythm electrocardiograms obtained. These parameters were measured before rebreathing, during the treatment immediately after a subject had signalled that he could no longer continue, and 3 minutes after treatment termination. After a rebreathing session was completed, the air in the bag was analyzed to determine percentage of oxygen and carbon dioxide.

Before rebreathing, patients showed higher systolic blood pressure and minute blood volume, and lower total peripheral resistance than normal subjects. These patients showed no signs of hyperventilation, however. The direction of responses of the two groups of subjects to rebreathing was the same. However, patients displayed greater increases in systolic blood pressure and minute blood volume toward the end of the treatment. Patients showed moderate compensatory decrease (10%) in peripheral resistance, while healthy subjects displayed a slight increase in this parameter. Three patients developed sinusoidal arrhythmia during rebreathing. Although the gas composition of exhaled air was similar in both groups at the end of the test, minute respiratory volume and mean maximal inhalation rate over one minute increased more in normal subjects. Healthy subjects were able to tolerate rebreathing substantially longer, which the authors attribute to their greater maximum possible respiratory duration (20% higher than patients).

Table: Cardiorespiratory parameters in response to a hypercapnic-hypoxic gas medium in healthy subjects and patients with neurocirculatory dystonia

Figure: Sample rhythmocardiograms

CARDIOVASCULAR AND RESPIRATORY SYSTEMS

P705(16/88)* Belkaniya GS, Galustyan MV, Dartsmeliya VA, Demin AN.
Hemodynamic effects of beta-adrenoblockade by obzidan in horizontal and upright positions.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(6): 90-94; 1987.

[15 references; 5 in English]

Cardiovascular and Respiratory Systems, Hemodynamics

Humans, Males, Typology

Beta-Adrenoblockade, Drugs, Obzidan, Horizontal and Vertical Postions

Abstract: A total of 34 volunteers participated in this study. After 15-20 minutes of adaptation to either an upright or horizontal position subjects were given a single therapeutic dose (40-80 mg) of the beta-blocker obzidan [1-1 Isopropylamino-3(1-naphtoxy)-2-propanol hydrochloride]. Hemodynamic shifts were studied on minutes 15, 30, 40, and 60 after administration of the drug. Normative hemodynamic data had previously been obtained for 147 healthy males in the positions studied. These norming subjects were divided into circulation regulation types on the basis of changes in minute circulatory volume in upright position compared to horizontal position. The hypokinetic (I) type (74% of subjects) was defined as those in whom upright minute volume was less than 94% of the horizontal parameter; the eukinetic type (II) (12% of subjects) showed orthostatic minute volume 94-106% of horizontal; while the hyperkinetic type (III; 14% of total) had parameter values over 106% of total). In the current experiment parameters measured included: blood pressure, circulatory stroke volume, minute blood volume total and specific peripheral resistance, and mean blood pressure. Myocardial contraction function was assessed on the basis of amplitude of a differential chest plethysmogram reflecting speed of cardiac ejection. Arterial blood flow in the limbs and visceral organs was assessed on the basis of plethysmograms of the abdomen, thighs, and calves; venous blood flow to the heart on the basis of the difference between percentage changes in peripheral and central impedance. An index of peripheral resistance was computed from the difference between relative changes in arterial flow and cardiac stroke volume.

The subjects were divided into the 3 types defined above; 62% were defined as hypokinetic; 18% as eukinetic; and 20% as hyperkinetic. A correlational analysis disclosed a high negative linear correlation between values of cardiac stroke volume and minute blood volume in horizontal position and hemodynamic response to obzidan in this same position. No such correlation existed for vertical position. However, there was a high positive correlation between circulation regulation type and the hemodynamic effects of obzidan in both standing and supine position. Major effects for different types are shown in the table reproduced below.

The authors interpret their data as indicating that the orthostatic reaction types identified reflect substantially different mechanisms for regulating central and peripheral circulation, which are manifested in differences in cardiovascular reaction to beta-blockade. The differences in response to beta-blockers in supine and standing positions emphasize the significant differences between these states with respect to regulation of circulation and reactivity of the cardiovascular system. The finding that the hemodynamic effects of beta-blockers on the cardiovascular system depends on reactivity type opens the possibility of prediction of hemodynamic effects of

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adrenoblockers and individually tailoring pharmacological measures used.

Table 1: Correlations between baseline values of circulatory stroke volume and minute blood volume in horizontal and upright position and changes in them upon administration of the beta-blocker, obzidan, in supine and standing positions

Parameter	Conditions		Correlation
	Baseline	Obzidan	
Circulatory Stroke Volume	Supine	Supine	-0.7*
	Supine	Standing	0.0
	Standing	Supine	+0.5**
	Standing	Standing	-0.9*
Minute Blood Volume	Supine	Supine	-0.6*
	Supine	Standing	+0.2
	Standing	Supine	+0.6*
	Standing	Standing	-0.9*

* p < 0.001

** p < 0.02

Table 2: Changes (in %) in parameters of peripheral circulation in subjects belonging to three orthostatic circulation types after administration of the beta blocker obzidan in supine (A) and standing (B) position

Parameter	Orthostatic Circulation Type					
	I		II		III	
	A	B	A	B	A	B
Venous blood flow to the heart (limbs)	+2	-15*	+6	+5	+8+	-10+
Venous blood flow to the heart (viscera)	-1	+7	+2	+4	+2	-3
Peripheral venous outflow (limbs)	+16	+19	+38	+24	+23	-19*+
Peripheral venous outflow (viscera)	-15	+7*	+12	+11	-2	+4
Arterial inflow (limbs)	+11	+10	+33	+16	+18	-18*+
Arterial inflow (viscera)	-12	0	+12	+4	+4+	-8
Resistance to arterial inflow (limbs)	-13	+64*	-25	+7*	+4+	-14**+
Resistance to arterial inflow (viscera)	+11	+76	-5	+7***	+25	-24*+

+ significant differences between types I and III; * p < 0.01, ** p < 0.02, *** p < 0.05 for differences between parameters measured in supine and standing positions

Figure 1: Normative characteristics of three types of central hemodynamics in upright position

Figure 2: Changes in major parameters of central hemodynamics after beta-blockade by administration of obzidan in supine and standing position for three orthostatic circulation types

CARDIOVASCULAR AND RESPIRATORY SYSTEMS

P715(16/88) Lapayev EV, Bednenko VS, Vorob'yev OA, Artamonov IN, Zaritskiy W.

The effect of vestibuloautonomic stimulation and hypokinesia on regional hemodynamics.

Izvestiya Akademii Nauk SSSR. Seriya Biologicheskaya.

1987(6): 805-813.

[31 references; 5 in English]

Cardiovascular and Respiratory Systems, Hemodynamics, Regional Humans

Neurophysiology, Vestibuloautonomic Stimulation, Coriolis Acceleration, Hypokinesia with Head-Down Tilt, Motion Sickness

Abstract: Subjects were 12 healthy individuals, aged 18-30, who were strapped lying on their backs to a special vestibulometric stand which permitted simultaneous hypokinesia with head-down tilt (-10°) and Coriolis acceleration while moving the head in the sagittal plane during rotation around the vertical axis in the head region. Above the subject's head was a movable disk with alternating dark and light stripes subtending angles of 6 degrees. The disk rotated around the vertical axis passing through the area of the head, creating optokinetic stimulation simultaneous with the other two forms. Duration of exposure to head-down tilt was 6-8 hours, while Coriolis and optokinetic stimulation lasted from 5 to 20-25 minutes (until moderately pronounced symptoms of motion sickness occurred) at intervals of 1.5 to 2.0 hours. By the end of 4-8 hours of this treatment, subjects showed clear symptoms: sensations of discomfort and nausea, general weakness, apathy, hyperhidrosis, pallor of the face, and others. Electrocardiograms were recorded from 11 standard leads and blood pressure was measured in the brachial artery to monitor subjects' general condition. An ultrasound flow meter was used to measure linear rate of blood flow in the left and right carotids and vertebral arteries. Echography performed while subjects held their breaths for a brief period was used to obtain echograms of the cardiac ventricle in diastole, right lobe of the liver, spleen, left and right kidneys, and medial lobe of the right lung. These data were used to compute size parameters of the organs.

Results showed that subjects fell into two groups: those for whom linear blood flow and organ size parameters increased due to the stimulation and those for whom these parameters decreased. The predominant tendencies included decrease of blood flow rates in the carotid and right vertebral arteries, and also the jugular vein, moderate decreases in the dimension and volume of the right cardiac ventricle and liver, increased size of the left kidney, and increased concentration of blood and fluid in pulmonary tissues. The authors conclude that these results confirm the presence of marked hemodynamic shifts in the human body in response to the stimulus conditions used.

Table 1: Changes in blood flow rate parameters in vessels of the head in response to combined effects of hypokinesia with head-down tilt, Coriolis acceleration and optokinetic stimulation

Table 2: Changes in parameters of internal organ dimension in response to combined effects of hypokinesia with head-down tilt, Coriolis acceleration and optokinetic stimulation

DEVELOPMENTAL BIOLOGY

(See also: Musculoskeletal System P714; Radiobiology: P688)

PAPERS:

P689(16/88)* Benova DK. (Hungary).

Study of the genetic structures of sex cells of rats after flight on the Cosmos-1514 biosatellite during prenatal development.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(6): 24-27; 1987.

[15 references; 5 in English]

Developmental Biology; Genetics; Reproductive Biology, Spermatocytes
Rats, Female, Pregnant; Male
Space Flight, Cosmos-1514

Abstract: Female Wistar rats were flown onboard the Cosmos-1514 biosatellite during days 13-18 of pregnancy. On day 23 of the pregnancy after reentry, one of these rats gave birth. Male offspring were studied until sexual maturity and then sacrificed on day 102 of their lives. Synchronous and vivarium control groups were also studied. A preparation was made from the testes for cytogenetic analysis. Approximately 200 spermatocytes in diakinesis-metaphase I were analyzed. Reciprocal translocations in the form of multivalent rings or chains were counted. A number of researchers were used to confirm the count in ambiguous cases.

Of the 815 cells of flight rats studied, only 7 (0.9%) were identified as displaying translocations. This rate was significantly greater than that of the vivarium group, but not statistically greater than that of the synchronous control. These results indicate that space flight induces, although to a very slight extent, mutations in gonocytes. These mutations evidently are induced not only by weightlessness, but by other extreme factors, such as vibration, acceleration, noise and impact. However, the role of weightlessness cannot be ruled out.

Table: Reciprocal translocations in rats exposed to space flight during embryonic development on the Cosmos 1514 biosatellite

Group	N	Subject Number	Weight, g	# Cells Analyzed	Cells with Translocations, %	Type of Association	
						Ring	Chain
Flight	4	1	375	209	0.5	—	1
		5	375	198	0.5	1	--
		9	392	208	1.5	1	2
		12	413	200	1.0	1	1
Synchronous control	4	55	280	200	1.5	1	2
		59	326	198	0.0	—	--
		70	350	199	0.5	1	--
		78	408	201	0.0	—	--
Vivarium control	4	27	375	200	—	—	--
		34	385	200	—	—	--
		48	390	200	—	—	--
		49	392	203	—	—	--

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Figure 1: Normal plate of spermatocyte in diakinesis-metaphase I.



Figure 2: Plate of spermatocyte in diakinesis-metaphase I -- translocation carrier.

P734(16/88) Oyglenblink ZA.

Growth and development of larva of Rana temporaria after exposure to increased gravity.

In: Gizenko OG (editor).

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**].

Moscow: Nauka; 1986.

See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.

Pages: 288-289.

Developmental Biology, Growth and Development, Larva
Amphibians, Frogs, Rana temporaria
Gravitational Biology, Increased Gravity, Centrifugation

Abstract: It is well known that exposure of developing amphibian embryos to increased gravitational force induces abnormal development and increases the death rate during embryonic stages. Typically, some of the developmental abnormalities are compensated for; anatomically normal tadpoles hatch. However, during larval development, especially metamorphosis, complex morphological restructurings occur, which may be affected by incomplete regulation of outwardly invisible anomalies of development. With this goal we designed experiments to study survival rate, and growth and development of Rana temporaria tadpoles hatched from ova subjected to centrifugation with acceleration of 2- and 3-G, from the grey sickle to the gastrula stage. Centrifugation was performed on two different BMTs-1 centrifuges, the design of which allowed the use of 6 egg masses. Samples of 200-250 ova were taken from each mass for both the control and experimental conditions. A total of 4000 ova were used. When hatching began to occur, it was revealed that the effects of 2- and 3-G acceleration reliably decreased the number of anatomically normal living larvae and increased the number of anomalous ones. Death of ova in the embryonic stage was also increased. Individual differences in sensitivity to increased gravity across egg masses are relatively high in grass frogs. In order to exclude the effects of such individual differences, each experimental condition (2-G, 3-G) and the control used a mixture of anatomically normal tadpoles from all 6 egg masses. The tadpoles were placed in an aquarium with density of 100 larvae/15 l and 50 larvae/20 l to exclude the effects of density, which, as is well known, have a strong effect on rate of ontogenesis and viability of tadpoles. Body length from the end of the head to the anal opening was measured at the stage of posterior limb buds, and before and after metamorphosis. At these times we counted the number of tadpoles and young frogs. Tadpoles in the experimental conditions developed at the same rate as controls. Differences in growth rate and viability were not found. Mortality did not increase during metamorphosis in experimental groups. Thus the weak developmental anomalies occurring as a result of increased gravity during embryonic stages are fully compensated for.

ENDOCRINOLOGY

(See also: Body Fluids P743; Immunology P706; Metabolism BR 12)

PAPERS:

P690 (16/88)* Alekseyev YeI.

Morphofunctional state of the hypothalamus-pituitary neurosecretory system in rats exposed to space on the Cosmos-1667 biosatellite.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(6):27-31; 1987.

[7 references; 7 in English]

Endocrinology, Hypothalamus-Pituitary System; Morphology; Body Fluids
Rats, Males
Space Flight, Short-term, Cosmos-1667, Gravitational Biology,
Centrifugation, Hypokinesia

Abstract: This experiment investigated the hypothalamus and pituitary glands of 4 male Wistar-SPF rats sacrificed 4-6 hours after reentry from a 7-day space flight. A synchronous control group contained 4 rats and a vivarium control group contained 5. The hypothalamus of rats undergoing 4- or 8-hour periods of centrifugation at 2-G or 7 days of hypokinesia were also studied. Each manipulation was performed on 5 rats. In all conditions, gland tissue was fixed and a series of horizontal cross-sections 5 um wide was prepared. Staining was used to identify neurosecretory substance in the neurons of supraoptical nuclei of the hypothalamus and in axons of the posterior lobe of the pituitary, and ribonucleoproteins in neurosecretory cells. Karyometry was also performed.

In rats, the functional state of the supraoptical nuclei is indicated by the proportions of "light" and "dark" neurons. Light neurons contain vasopressin, an antidiuretic hormone which predominates in normal male rats. Although the morphological structures of these nuclei were comparable in the flight and control groups with respect to shape and size and predominance of light cells, flight rats displayed a sharply reduced total concentration of ribonucleoproteins and neurosecretory substance in the cytoplasm of light cells. In almost all cells, accumulation of neurosecretory substance in the perinuclear synthesis zones, characteristic of normal animals, was virtually absent. Decrease of ribonucleoproteins and neurosecretory substance in neuronal cytoplasm was accompanied by a reliable decrease in the size of neuronal nuclei. Rats in the synchronous control experiment were equivalent to rats in the flight group with regard to concentration of ribonucleoproteins and neurosecretory substance, but their nuclei were larger. Unlike the two control groups, rats in the flight groups showed marked broadening and moderate elevation of axons at the level of the supraoptical nuclei. There was no neurosecretory substance in many of the lumens. In addition, there was a marked decrease in the optical density of neurosecretory substance in the axon terminals and Herring bodies of the anterior pituitary lobe, clear hypertrophy of pituicytes, and an increase in small pituicytes with branching contours. The author considers the main changes in the flight group to be accelerated transport of neurosecretory substance from the bodies of supraoptical nuclei to the abducting axons and signs of decreased synthesis of antidiuretic hormone, such as decreased size of neuronal nuclei, almost total absence of granules containing neurosecretory substance in the synthesis zone and decreased content of

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neurosecretory substance in the posterior lobe of the pituitary. Animals centrifuged for 4 hours showed increased secretion of neurosecretory substance from supraoptical neurons, accompanied by broadening of the majority of axons and decreased granular secretion in the lumens. There was increased hormonal accumulation in the axon terminals, while the concentration in the Herring bodies was normal. After 8 hours of centrifugation, concentration of neurosecretory substance returned to normal levels in the neurons, axons, and terminals of neurosecretory fibers of the posterior pituitary lobe. Centrifugation did not affect synthesis of antidiuretic hormone in the supraoptical nucleus and concentration of ribonucleoproteins was at control level. No morphological changes were found after hypokinesia.

The authors conclude that, since none of the subjects in the ground simulations showed morphological signs of depressed production of ADH-vasopressin in the neurons of the supraoptical nucleus, the inhibition of production of that hormone in the flight group may be attributed to weightlessness. Since rats centrifuged for 4 hours showed increased neurosecretion from the supraoptical nucleus and its axons at the level of the posterior pituitary lobes (similar to results for the flight group), it may be concluded that this effect developed at the end of the flight in response to acute gravitational stress. Inhibited ADH and vasopressin production could facilitate loss of fluid and establishment of a new level of hydration in the early period of adaptation to weightlessness, while increased secretion of the hormone into the blood in the first few hours post reentry evidently serves to facilitate fluid retention or prevents fluid loss upon return to normal gravity.

Table: Karyometric data on the neurons of the supraoptical nucleus of the hypothalamus and pituicytes of the posterior lobe of the pituitary in rats

Group	Neurons	Volume, μm^3		p
		p	Pituicytes	
Vivarium control	402.0	—	132.2	—
Flight group (7 days)	341.9	<0.001	121.2	<0.02
Synchronous control	464.8	<0.001	130.0	<0.6
Centrifugation:				
4 hours	416.3	<0.6	126.1	<0.2
8 hours	417.0	<0.6	128.5	<0.2
Hypokinesia (7 days)	404.8	<0.6	135.0	<0.6

p = significance of difference from vivarium control

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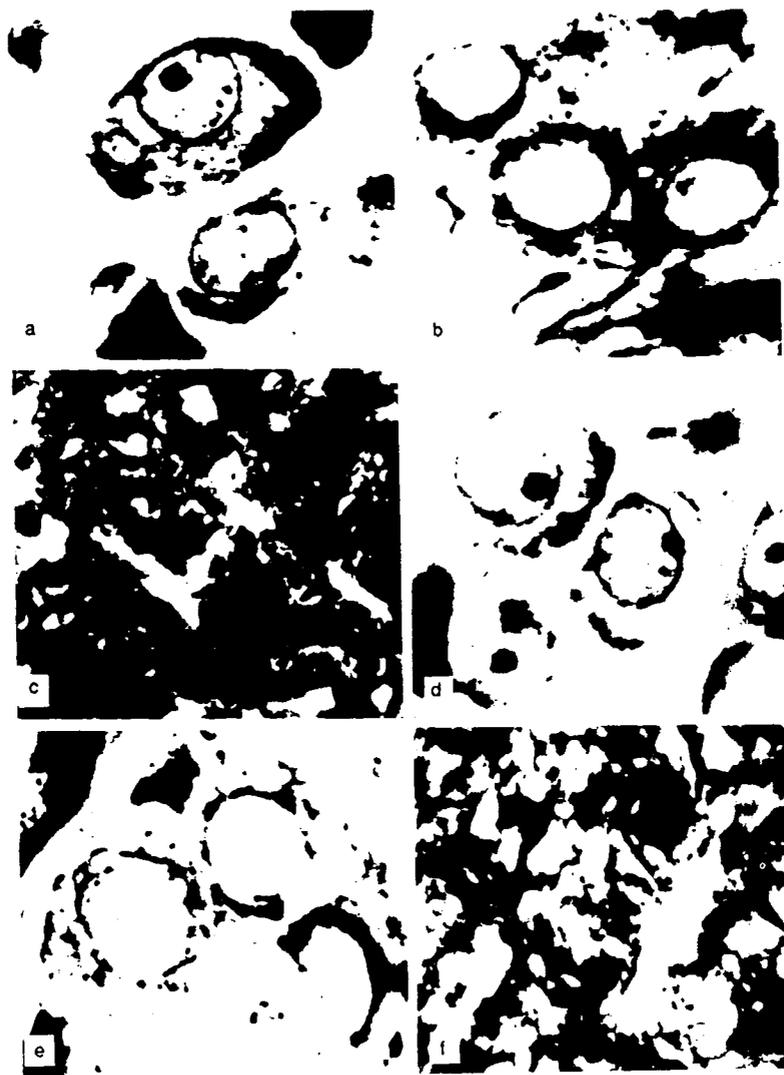


Figure: Hypothalamus and posterior lobe of the pituitary
 a - c - control. Note marked condensation of ribonucleoproteins (a) along the periphery of the cytoplasm and accumulation of granules of neurosecretory substance (b) near the nucleus of the supraoptical nucleus neurons. In the posterior lobe (c), the lumens of small and large axons are moderately full of neurosecretion. d - f - flight group (4-6 hours postflight). There is a sharp decrease in the concentration of ribonucleoprotein (d) and neurosecretory substance (e) in the neurons of the supraoptical nucleus. In all types of axons of the posterior lobe (f) concentration of neurosecretion is noticeably depressed.
 Ob. 100, ok. 7 (a,b,c,d) ob. 40, ok.7 (e,f)
 Stained with gallocyenin (a,f) and paradehydofuchsine (b,c,d,e)

P700(16/88)* Artsruni GG, Zil'fyan AV, Azgaldyan NR, Dovlatyan RA.
The effect of an external electric field on catecholamine secretion of the adrenal glands of rats.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(6):67-70; 1987.

[10 references; 2 in English]

Endocrinology, Adrenal Glands, Catecholamines

Rats

Electric Field, External

Abstract: This experiment examined the biological effects of electric fields on catecholamine secretion of the adrenal glands of rats. Pilots encounter examples of such fields when they fly below thunder clouds. Subjects were 86 white outbred male rats exposed to an electric field of 200 kV/m. In different conditions rats were exposed to the field for 1 hour, 1 day, or 6 days for 6 hours per day. Animals were sacrificed immediately after exposure at the same time of day. In a subset of each exposure group blood adrenalin and noradrenalin, and concentration of adrenalin, noradrenalin, DOPA, and dopamine in the adrenal glands were measured spectrofluorimetrically. In another subset the adrenal glands were fixed, stained, and cryostatic sections studied to determine the local distribution of catecholamines.

After 1-hour exposure to the field, the experimenters observed sites of disintegration in the secretory apparatus of adrenal chromaffin tissue. These sites contained cells with highly vacuolized cytoplasm and a large white chromatin nucleus. Quantitative analysis of the catecholamines using a fluorescent microscope revealed a marked decrease in concentration of cytoplasm in secretor cells. In addition, concentration of catecholamines increased in the blood of these animals. After 1 day's exposure, the most pronounced results in the chromaffin tissue were widening of the sinuses, and hemostasis and hyperemia of the organ. The walls of the sinuses and neighboring tissue were impregnated with plasma proteins. A large number of blood cells were present in the lumens. Secretor cells near the sinuses were flattened and showed signs of dystrophy. Catecholamine concentration in adrenal tissue was depressed, but there were some sites of fluorescence generally in cells bordering the sinuses. Blood levels of adrenalin and noradrenalin were almost doubled. Repeated exposure to the field disrupted the structure of the adrenal cortex. Most secretor cells were light, with pronounced vacuolization of the cytoplasm and signs of nuclear polymorphism. Concentrations of adrenalin and noradrenalin in both the adrenal gland and the blood was sharply decreased. Concentration of DOPA was diminished in adrenal tissue after 1-day and 6-day exposure to the field. Dopamine increased after 1-hour exposure.

The authors conclude that 1-hour's exposure to the electric field was associated with activation of the secretor apparatus of adrenal chromaffin tissue and accompanied by enhanced secretion of catecholamines into the blood. After 1-day's exposure, catecholamine level was elevated in the adrenal glands and blood, while the cytoangioarchitectonic structure of the organ was disrupted, testifying to excessive functional stress on the secretor apparatus of the adrenal cortex. Repeated exposure to a field leads to a decreased level of catecholamines in the blood and decreased adrenal chromaffin activity.

ENDOCRINOLOGY

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Table: Concentration of catecholamines after exposure to an electric field of 200 kV/m

Figure 1: Chromaffin tissue of the adrenal glands of rats exposed to an electric field

Figure 2: Distribution of catecholamines in adrenal chromaffin tissue in control and experimental rats

P733(16/88) Kvetnyanski R, Torda T, Blazhichek P, Chulman Yu, Makho L, (Czechoslovakia).

Study of the levels of catecholamines and adrenergic receptors in rats after flights on Cosmos biosatellites.

In: Gazenko OG (editor).

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986].

Moscow: Nauka; 1986.

See: Abstract M117 (Space Biology and Medicine), Digest Issue 14.

Pages: 275-276.

Endocrinology, Sympathetic-Adrenal System, Catecholamines, Adrenergic Receptors; Enzymology
Rats, Males; Reproductive Biology, Females
Space Flight, Short-term, Cosmos-1129, -1667, Psychology, Immobilization Stress

Abstract: Experiments performed on Cosmos biosatellites studied the effects of space flight factors on the state of the sympathetic-adrenal system in Wistar rats. In addition, the levels of catecholamines in plasma and tissues, enzyme activity, synthesis, and degradation and the number of adrenergic receptors were determined.

Animals examined on the day of reentry did not reveal any significant changes compared to control animals in concentration of adrenalin, noradrenalin, or activity of catecholamine-synthesizing enzymes in the kidneys. In the experiment on Cosmos-1129, animals which had just returned from space were subjected to a series of immobilization stress tests. The sympathetic adrenal system appeared sensitized to the effects of an additional stressor. Animals in the experimental group showed greater increases in adrenalin and activity of tyrosine hydroxylases in the kidneys than did control animals.

Female rats exposed to weightlessness during days 13-18 of pregnancy displayed reliable changes in catecholamine metabolism in the kidneys, which may result from the greater reactivity of pregnant animals exposed to weightlessness.

The myocardia of male rats exposed to space flight displayed increased concentrations of noradrenalin and adrenalin, without changes in enzyme activity, catalyzing synthesis or catecholamine inactivation (with the exception of PNMT). These results support the hypothesis that the noradrenalin neurons supporting sympathetic innervation of the myocardium are less active in weightlessness. On the other hand, it would seem that synthesis of adrenalin in myocardial neurons increases. Concentration of adrenalin in the heart, however, is an order of magnitude below concentration of noradrenalin.

Typically, activation of the sympathetic adrenal system is accompanied by increased level of catecholamines and decreased quantity of adrenergic beta-receptors in the heart, spleen, and other organs. These are precisely the type of changes we expected to obtain under space flight conditions.

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In an experiment on Cosmos-1667 we observed the opposite situation: the quantity of beta-receptors in the heart and spleen of rats in the flight group was reliability greater than that of the control. These data reflected decreased activation of sympathetic regulation in these organs during space flight. It is possible that in this case we were seeing a specific effect of space flight on the regulation of receptors, which has not yet been studied in space experiments.

In summary, the results obtained indicate that sympathetic adrenal system activity did not alter significantly under the influence of space flight and, evidently, a long-term state of weightlessness is not a stressogenic stimulus for this system.

ENZYMOLGY

(See also: Endocrinology P733; Nutrition P740)

PAPERS:

P704(16/88)* Vetrova YeG. Popova IA.

Activity of oxidative enzymes in response to graded physical exercise in healthy individuals and patients with neurocirculatory dystonia.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(6): 86-89; 1987.

[9 references; 4 in English]

Enzymology, Oxidative Enzymes; Metabolism
Humans, Patients, Neurocirculatory Dystonia
Physical Exercise

Abstract: Dehydrogenase activity was measured in 3 groups of subjects of approximately the same age during a 7-day stay in a clinic without drug treatment. The first group consisted of 10 healthy men, the second group of 10 individuals suffering from hypertonic neurocirculatory dystonia, and the third group of 9 individuals who had hypotonic neurocirculatory dystonia. Physical exercise was performed in a supine position on a bicycle ergometer at a rate of 50 and 75% maximum loading as determined by pulse frequency, with age, weight, and sex taken into account. Venous blood was taken using a catheter 2 days before the study, directly preceding it, when 50 and 75% of maximum rate were attained, and 30 minutes after the exercise was terminated. Activity of NADP-dependent malate dehydrogenase (MDH) and NADP-dependent isocitrate dehydrogenase (IDH) were determined using enzyme spectrophotometry. Distribution of malate dehydrogenase isoenzymes was determined using electrophoresis.

In the baseline period total activity of both enzymes was within normal limits for all 3 groups. Level of cytoplasmic fraction MDH₁ was significantly elevated in group 2. MDH₂ showed a nonsignificant tendency to be depressed in group 3, while MDH₃ tended to be elevated. During exercise MDH activity increased at 50% loading in all 3 groups and continued to increase at 75%. After 30 minutes, malate dehydrogenase activity decreased in all groups, reaching baseline only in healthy individuals. No changes were found in MDH fractions for any group at any period. Exercise increased isocitrate dehydrogenase activity in all groups; this activity dropped 30 minutes after treatment. The authors conclude that intense physical exercise stimulated metabolic processes, leading to increased activity of oxidative dehydrogenases in blood serum. However, both increases and recovery are slower in subjects suffering from neurocirculatory dystonia.

Table 1: Activity of malate dehydrogenase and isocitrate dehydrogenase in blood serum [Note: labels for enzymes appear to be reversed in this table.]

Table 2: Distribution of isoenzymes of malate dehydrogenase in blood serum

EXO BIOLOGY: See Space Biology P732
GASTROINTESTINAL SYSTEM: See Operational Medicine P723

GENETICS

(See also: Developmental Biology P689; Endocrinology P690; Radiobiology P713)

PAPER:

P736(16/88) Smirnova AV.

Frequency of nondisjunction of sex chromosomes under conditions of altered gravitational force.

In: Gazenko OG (editor).

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**].

Moscow: Nauka; 1986.

See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.

Pages: 295-296.

Genetics, Nondisjunction of Sex Chromosomes

Insects, Drosophila, Female

Gravitational Biology, Altered Gravity, Clinostatting, Acceleration;
Radiobiology, Gamma-Irradiation

Abstract: Recent achievements in the science and technology of cosmonautics have made it possible for humans to spend long periods of time in space. As a result, there is an urgent need for biomedical research to support space flight safety. One of the issues in this research area is study of the effects of space flight factors on genetic structures and processes. One of the main genetic tests used to determine whether chromosomal material is affected by exposure to novel factors is to test nondisjunctions or mutation of sex chromosomes. Nondisjunction of sex chromosomes, leading to aneuploidy, causes serious genetic diseases in humans, such as Downs syndrome, Turner's syndrome, and others. Different biological species -- from bacteria to mice -- are traditionally used to evaluate genetic risk. Drosophila occupy an important position among these species.

Our research studied the effects of altered gravitational force, alone or combined with ionizing radiation, on frequency with which nondisjunction of sex chromosomes occurred in female Drosophila. The experiments utilized acceleration and clinostatting as a simulation of weightlessness, alone and in combination with gamma-radiation before or after centrifugation.

The results of the research showed that the effect of increased gravitational force up to 250-G for a period of 4 hours and clinostatting at a rate of 5 rev/min during the entire period of pre-imago development did not increase chromosome nondisjunction frequency. Mutation frequency under these conditions was 0.09 ± 0.03 and $0.05 \pm 0.01\%$, respectively, and did not differ significantly from the spontaneous frequency of this type of mutation. Irradiation in a dose of 5 Gy with dose rate of 1.25 Gy/min gave rise to a clear, statistically significant effect, which increased mutation frequency to $0.12 \pm 0.03\%$. Addition of acceleration and clinostatting in various combinations with gamma-irradiation made virtually no contribution

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to the radiation effect.

Thus, it was demonstrated that the effect of altered gravitational force, both increased and compensated for by horizontal clinostatting, did not induce increased frequency of sex chromosome nondisjunction and had no modifying effect on radiation mutagenesis in female Drosophila.

GRAVITATIONAL BIOLOGY

(See also: Developmental Biology P734; Genetics P736;
Musculoskeletal System P696)

PAPERS:

P718(16/88) Yegorov AD.

Mechanisms underlying changes in major physiological functions in humans exposed to weightlessness for long periods of time.

In: Gazenko OG (editor).

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aersp Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**].

Moscow: Nauka; 1986.

See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.

Pages: 58 - 60.

Gravitational Biology; Musculoskeletal System; Neurophysiology; Body Fluids
Humans, Theoretical Article
Weightlessness, Long-term

Abstract: Analysis of the mechanisms underlying changes in the major physiological functions and adaptation of the human body to weightlessness is an important prerequisite for creating an efficient system of prophylactic measures and for selecting the main directions of medical research during long-term space flights. The lack of mechanical stress or deformation on the body associated with normal gravity is the major reason for the physiological effects of weightlessness. This causal factor precedes and triggers all the other effects that result in changes of physiological functions in space. This direct effect of weightlessness causes functional unloading in a number of physiological systems.

At present, in gravitational biology it is postulated that gravity affects the structural elements of a body only if they are of sufficient mass. Mathematical calculations, corroborated by biological experiments in space, have demonstrated that the gravitational field of the Earth affects isolated cells or their structures only if they are greater than one micron in size. From this it follows that intracellular and molecular processes (synthesis of DNA, RNA proteins, enzymatic processes, transmission of genetic information, genetic recombination and reparation), as well as the vital process of cells in general, evidently, do not depend on gravitation and are not altered in weightlessness. According to current ideas, the critical size for a portion of tissue which is not affected by the force of gravity is about one millimeter; below this size molecular attraction plays the dominant role. However, in the body as a whole, the displacement of organs and tissues may affect smaller structures, particularly, receptor cells. Theoretical analysis based on general physiological concepts concerning the functioning of mechanoreceptors supports the hypothesis that not only are there qualitative changes of afferent impulses in weightlessness, but there is also a decrease in total flux from the mechanoreceptors, leading to a change in the functional organization of sensory system processing. Change in afferent impulses and the interaction of afferent systems may induce adaptive restructuring of the functional states of a number of physiological systems, including development of

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sensory conflicts, changes in the activity of the reticular formation, cortico-subcortical interactions, hypothalamus-pituitary system, and regulation of autonomic functions.

The uniqueness of the situation, as signalled by ambient afferentation, and the absence of a model of this situation in "memory" impedes the development of a plan of action and selective blockade of the functional links between neurons, which may lead to search for the optimal solution by realization of the goal of results. For this reason, acquisition of individual experience, search for and selection of the optimal form of physiological response takes a certain period of time.

Change in the distribution of body fluids in weightlessness, which is manifested in cranial shifts, evidently induces increased pressure in the cardiopulmonary area and secondary changes in afferentation from a number of receptor zones, leading to reflex restructuring of circulation, and changes in fluid-electrolyte balance and microcirculation.

Decrease in postural-tonic activity and loading of antigravity muscles, as well as the constant deficit of muscle activity induces not only restructuring of the neuromuscular apparatus but can also, on the one hand, lead to decreased rate of oxidative processes, structural plasticity and transport support of a number of physiological functions, and on the other hand, to decreased role of the muscle system in hemodynamics.

The shifts in vital parameters induced by the effects of weightlessness trigger self-regulation mechanisms and development of assimilative reactions, preventing further progress of deviations and, to some extent, ameliorating them. The process of assimilation to space flight conditions is a function of time and may be divided into periods using one or another technique. The effects of weightlessness on long-term space flights can be compensated for, to some degree, by a system of prophylactic measures which makes it more difficult to study the effects of this factor in a pure form.

P735(16/88) Parfenov GP.

The effect of the force of gravity on animal cells and organisms.

In: Gizenko OG (editor).

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986].

Moscow: Nauka; 1986.

See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.

Pages: 289-290.

Gravitational Biology, Animal Cells and Organisms

Theoretical Article, Microbiology, Eukaryotes, Prokaryotes; Multicellular Animals

Force of Gravity

Abstract: One often reads or hears that all living forms, from the moment life arose, have been exposed to the constant and invariant influence of gravity, and that this, to a significant degree, has determined their evolution, and modern forms and functions. In spite of the seeming self-evidence of this assertion, at present it makes sense only with an important clarification. Cells of archi- and prokaryotes, although they have existed in a gravitational field from the time they arose, i.e., more than three billion years ago, cannot feel its effects. Cells of eukaryotes may be three or even four orders of magnitude larger than prokaryote cells. In these cells, the forces which arise as a consequence of the laws of thermodynamics and gravity may be comparable in intensity. However, it is not very probable that gravity has a direct effect on individual eukaryote cells, since they are partitioned by an intracellular membrane and are, in essence, an integrated pool of prokaryotic cells. Furthermore, the surface membranes of the cells are exceedingly strong structures and thus, aside from their major functions, effectively play the role of supporting elements. The appearance of animal-vegetable polarities may also be observed in certain prokaryotes. In protozoa, polarity of structure is more often the rule than the exception. The structure of almost all representatives of the classes of Ciliata and Flagellatae are polar. There is no doubt that the appearance of polarity in unicellular, and subsequently multicellular organisms, is a manifestation of secondary adaptation to the polar effects of the force of gravity. The origin of polarity is a consequence of living in an environment with an "up" and a "down" and not a direct evolutionary adaptation to the effects of gravity on the cell. The direct evolutionary and physiological effects of gravity occur only in larger multicellular animals. Thus, it makes sense to speak of the direct effects of gravity on forms of life, only if one is referring not to the entire period since life arose, but only to the period after the appearance of larger land animals, a timespan a great deal shorter than one billion years. The effect of the force of gravity on animals depends on their weights. In other words, gravitational tolerance is inversely proportional to body weight. This fact is generally known and does not require further proof; however, it does require explanation, commentary, and quantitative investigation. The association between the major vital processes and body weight can be expressed by the equation: $E_{min} = am^b$. The gravitational tolerance curve is a hyperbola, the initial descending portion of which is almost vertical, indicating that small land animals up to certain critical values of weight are virtually unaffected by the force of gravity. By

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certain estimates, this critical value for weight is several grams.

When we consider the problem of the effects of gravity and weightlessness on an organism, we must start with the fact that effects on individual cells of a multicellular organism are always secondary. They are mediated by reactions of the organism as a whole, or more accurately, by the reactions of certain of its systems and organs. First and foremost this includes the vestibular apparatus, supporting structures and tissues, and body fluids. When we consider the gravitational significance of body fluids, we must not forget that living organisms leaving the sea and becoming land animals "brought some of the ocean with them," since like aquatic organisms, all their cells are suspended in a liquid medium. The reactions of the vestibular apparatus, supporting tissues and body fluids to changes in the force of gravity, as mediated by the neural and endocrine systems, lead to complex stress-induced and adaptive changes in organs and organ systems, which frequently induce changes in their cellular constituents.

GROUP DYNAMICS

PAPER:

P730(16/88) Miroshkina MB, Sled' AD.

Cooperative activity and dynamics of intergroup interactions of an isolated small group.

In: Gazenko OG (editor).

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**].

Moscow: Nauka; 1986.

See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.

Pages: 189-190.

Group Dynamics, Small Group, Isolated, Group Performance

Humans

Intergroup Interactions, Interaction Style

Abstract: Increases in the number of autonomous groups performing industrial tasks and their high economic importance presents a number of problems for social psychology. Among these is evaluating the effectiveness of interactions in between a small autonomous group responsible for operational activity (ingroup) and a larger consultative group (outgroup) remote from the working location.

In our work we studied the effects of style of intergroup interaction on the effectiveness of the ingroup's performance of productive tasks that could be accomplished only with cooperative interaction between the in- and outgroups. To evaluate the style of intergroup interactions, we identified the factors of democracy — authoritarianism (factor A) and formality -- informality (factor B) as parameters of verbal interaction. Each end of the scale was associated with a set of referents which made it possible to identify the strength of each factor.

To evaluate the social attitude of members of the ingroup toward intergroup interaction with the outgroup we used a choice matrix involving cognitive and emotional choices and an original survey. The style of intergroup interaction was determined using content analysis.

Analysis of the results showed a positive correlation between the effectiveness of cooperative group activity and the style of intergroup interaction initiated by the outgroup for factor A. It was demonstrated that a formal authoritarian style of intergroup interaction leads to the formation in the ingroup of tendencies to autonomize their activities and develop a progressively more negative attitude toward intergroup interaction. On the basis of these results we recommend this set of methods for use under conditions of intergroup interaction among professional groups to improve the style of intergroup interaction and thus increase the efficacy of cooperative intergroup activity.

**HABITABILITY AND ENVIRONMENT EFFECTS: Human Performance P741;
Man-Machine Systems M120**

HEMATOLOGY

(See also: Mathematical Modeling P739; Radiobiology: P712, 713)

PAPERS:

P694(16/88)* Pak GD, Sverchkova VS.

The role of carbon dioxide in correction of coagulation hemostasis under exposure to hypoxia.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(6):43-47; 1987.

[13 references; 2 in English]

Hematology, Coagulation Hemostasis, Fibrinolysis

Dogs

Hypoxia, Hypercapnia

Abstract: This experiment studied the coagulative and fibrinolytic properties of blood under hypoxic and hypoxic-hypercapnic conditions and attempted to analyze the relationship between hemocoagulative responses and level of hypoxemia and blood acidity. Subjects were 23 outbred dogs anaesthetized while breathing hypoxic (10% O₂ in nitrogen) and hypoxic-hypercapnic (10% O₂, 5% CO₂ in nitrogen) gas mixtures. Blood was sampled from the lateral branch of the femoral artery before the experiment while subjects breathed ordinary air and after 25 minutes of breathing one of the gas mixtures. Parameters measured as indicators of coagulative hemostasis included: silicon time for plasma, kaolin time for plasma rich and poor in thrombocytes; test for cold activation of a kallikrein "bridge" between factors XII and VII; thrombin time and free heparin; activity of antithrombin III; ethanol test; activity of the fibrin-stabilizing factor; concentration of fibrinogen and fibrinolytic activity; nonenzymatic fibrinolysis; index of the range of contact activation and index of liberation of thrombocyte activators; index of nonenzymatic and enzymatic fibrinolysis. Oxygen stress, carbon dioxide stress and pH of arterial blood were also measured and acid-base status parameters derived.

Breathing the hypoxic mixture led to a significant increase in the coagulative potential of blood. Silicon and kaolin time (particularly for thrombocyte-poor blood) and index of liberation of thrombocyte activation decreased, suggesting the appearance of a phospholipid component of platelets. Index of the contact activation range also decreased, confirming the presence of a hypercoagulative shift in response to hypoxia, caused by contact and phospholipid activation of mechanisms triggering clotting. Under hypoxic conditions, heparin activity decreased and there was a tendency for activity of the most potent anticoagulant -- antithrombin III to diminish. There was also a nonsignificant trend for cold activation time to decrease. The ethanol test remained negative. Fibrinogen concentration increased substantially, while indices of enzymatic and nonenzymatic fibrinolysis decreased. These changes were accompanied by increased flushing of CO₂ from the blood, increased pH and sharply (by 75%) decreased oxygen pressure. An increase in base deficit indicated the presence of incompletely oxidized metabolic products.

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Addition of 5% CO₂ to the breathing mixture prevented flushing of CO₂ from the blood and stabilized p_aCO₂ and pH at levels close to baseline. Deficit increased less than in the previous condition, suggesting more adequate oxygen supply to tissues. In addition, many parameters reflecting blood coagulation did not differ significantly from baseline. The only significant effects were increased concentration of fibrinogen, decreased fibrinase and heparin activity. Addition of CO₂ to the hypoxic medium did not inhibit nonenzymatic fibrinolysis, as in the previous condition. Significant differences between the hypoxic and hypoxic-hypercapnic media were found in the following parameters: silicon time, kaolin time for plasma rich and poor in thrombocytes, antithrombin III activity, and progressive decrease in activity of the fibrin-stabilizing factor.

The authors conclude that the addition of carbon dioxide to a hypoxic breathing medium prevents activation of the blood clotting that typically occurs in response to hypoxia. These data are considered very promising from the standpoint of developing nonspecific antihypoxic measures. Analysis of blood acidity and corrections of disorders in it are essential in the diagnosis and treatment of hypercoagulative states.

Table 1: Clotting activity of the blood in subjects breathing hypoxic and hypoxic-hypercapnic gas mixtures

Table 2: Gas composition and acid-base status of the blood in subjects breathing hypoxic and hypoxic-hypercapnic gas mixtures

Figure: Comparative assessment of the state of the blood clotting system in subjects breathing hypoxic and hypercapnic gas mixtures

HEMATOLOGY

P741(16/88) Kalandarova MP, Ushakov AS, Kravchenko VV.

Reactions of the blood system during adaptation to space flight conditions.

In: Gazenko OG (editor).

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986].

Moscow: Nauka; 1986.

See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.

Pages: 344-345.

Hematology, Hemopoiesis, Erythrocytes

Theoretical Article

Adaptation, Space Flight; Iron

Abstract: One of the most important topics in space hematology is the investigation of processes underlying changes in hemopoiesis under space flight conditions: bone marrow hypoplasia or physiological decrease in hemopoiesis (partial erythropoiesis). There is weighty evidence suggesting that the decrease in the functional activity of hemopoiesis (predominantly, erythropoiesis) is the leading factor in the development of shifts in the blood after exposure to space flight factors. Decreased erythropoiesis may be caused by lower body needs for erythrocytes when decreased motor activity leads to muscle hypo- or atrophy. This is an important, but not the sole, explanation for the decreased level of physiological regeneration of erythrocytes.

Reciprocal interactions with bone marrow cells may also develop; aside from the decreased number of cells of one type -- red (evidently not stimulated) there is an increase in the quantity of cells of the other types -- granulocytes (evidently, stimulated).

We also cannot exclude hypoplasia, which may be caused not only by the most frequent pathogenetic mechanism of bone marrow hyporegeneration, associated with a decreased number of stem cells, but by other factors such as adverse microenvironment (decrease in concentration of calcium and trace elements), immunologically mediated precursor cell destruction, and also insufficiency of regulatory hormones and inducing substances.

This paper discusses issues involving the role of iron in hyporegeneration of erythropoiesis. It should be emphasized that at present there is reason to believe that functional shifts occur in the blood system under the influence of space flight factors. These shifts are disadaptive with respect to the new environmental conditions. We also emphasize the importance of studying the functional activity of the blood system in extreme conditions, evaluating the maintenance of physiological reserves, studying pathogenetic mechanisms of bone marrow regeneration, and developing a scientifically based research program on the blood system with the goal of identifying early signs of hemopoietic stress.

HUMAN PERFORMANCE

(See also: Life Support Systems P731; Operational Medicine P717;
Psychology P726; P727)

PAPERS:

P708(16/88) Kamenskiy YuN.

The significance of critical flicker fusion frequency for assessing the state of an individual undergoing whole-body vibration.

Gigiyena Truda i Professional'nyye Zabolevaniya.

1987(7): 54-56.

[6 references; none in English]

Human Performance, Functional State; Perception, Critical Flicker Fusion Frequency

Humans, Males

Habitability and Environmental Effects, Vibration, Whole-Body

Abstract: Subjects were 10 healthy males exposed to sinusoidal whole-body vibration at discrete frequencies ranging from 2 to 63 Hz over the course of one hour. Subjects sat on a hard chair on the vibration platform. Light flashes were presented on an instrument held by the subject. Critical flicker fusion frequency was measured during a baseline period, during minutes 1-5, 10-15, 25-39, 40-45, and 55-60 of vibration and minutes 1-5, 10-15, and 25-30 post-treatment. Results showed that vibration in the range 5-12.5 Hz leads to a significant decrease in the fusion threshold parameter. In addition a decrease occurred of a vibration frequency of 40 Hz. No parameter change was noted at frequencies below 5 and above 12.5 (except 40). The authors conclude that the sharp decrease in critical flicker fusion frequency occurring at the beginning of exposure, lack of changes over the course of exposure, and immediate recovery after treatment termination, indicate that the source of the effect lies in the biomechanics of vibration, involving interaction of movement of the stimulus and movement of the head. The authors conclude that if flicker fusion frequency is being studied to evaluate effects of vibration on performance of tasks involved with driving a vehicle, then the experimental stimulus lamp should be held by the subject, since under actual conditions not only the operator's head, but also the instrument panel move, at frequencies that may not correspond. To investigate the effect of vibration on the functional state of the operator, the critical flicker fusion frequency should be measured under conditions where the operator's head and the stimulus lamp do not move relative to each other.

Table: Changes in critical flicker fusion frequency (in Hz) during 1-hour exposure to whole-body vibration

HUMAN PERFORMANCE

P709(16/88) Ponomarenko VA, Kostritsa VG, Yegorov SV, Oboznov AA.
A study of the reliability of pilot performance during long-term flights on automatic pilot.

Voyenno-Meditsinskiy Zhurnal.

1987(5): 43-45.

[no references]

Authors' Affiliation: [Military] Medical Corps

Human Performance, Flight Performance, Vigilance

Humans, Pilots

Long-term Flights, Monotony

Abstract: A total of 11 healthy operators who had mastered the skill of piloting participated in a 6-hour "flight" on automatic pilot in a training simulator. To enhance the monotony factor, lighting conditions simulated nocturnal lighting, and monotonous background noise was present. The operator had to monitor the changing values of flight parameters and report to the experimenter when the values fell outside of acceptable limits. He also had to track progress along the route and every 30 minutes make adjustments for a new set of intermediate points. In addition, every 25-30 minutes there were supplementary extraneous signals which had to be detected and analyzed immediately and decisions made concerning their nature. Performance parameters measured included: probability of detecting unacceptable flight parameter values (course, altitude, speed) and vigilance, measured as the ratio of the time required to respond to an extraneous signal in the absence of monotony to that required when monotony was present. Physiological parameters were EEG parameters, galvanic skin response, and heart rate. Additionally, subjects rated the way they felt on a scale anchored by excitement--sleepiness every 30 minutes. A questionnaire was given after the "flight" and behavior was monitored throughout with a video camera.

Performance was found to be stable at a high level for the first 2 1/2 hours of the session. Subsequently, there was a gradual decrease in performance parameters (manifested by a delay in recognizing unacceptable parameters). Performance was at a minimum after 4 hours and remained so until the completion of the experiment. At this point, delays in reporting unacceptable parameters ranged from 15-20 seconds to 3 minutes. The vigilance function showed a great deal of individual variation. The group function reached a minimum during the 3rd hour of the flight, gradually increased, returned to baseline at about 4 1/2 hours, and again fell. Heart rate and GSR fluctuated around baseline level throughout the experiment with some tendency to decrease toward the end. EEG changes appeared to fall into two phases; during the first 2 1/2 hours there were signs of decreased central nervous activation (increased alpha rhythm and decreased beta). Subsequently, this tendency reversed and the level of activation was higher than baseline level at the end of the experiment. Reports of sleepiness were most common during the first 2 1/2 hours. During the first 2-2 1/2 hours behavior was characteristic of classical response to monotony: minimal motor activity, masklike expression, half-closed eyes, fixed gaze, and yawning. Subsequently, these changes gradually diminished and motor activity increased, reaching a maximum toward the end of the experiment.

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At first glance, these results seem paradoxical. Physiological and behavioral signs of succumbing to monotony peaked after 2 1/2 hours and then declined. However, performance parameters continued to decline throughout the flight. The authors attribute this to a subject's active attempts to dissipate symptoms of monotony (e.g., singing, moving around), which while succeeding, also distract attention from the task at hand. Since data showed that performance improved when subjects were dealing with "intermediate points," the authors suggest that a promising way to improve performance under conditions of monotony is to increase the number of objectively definable stages in the flight.

Figure 1: Quality of monitoring of operation of automatic pilot by operators

Figure 2: Changes in vigilance over the course of the experiment

Figure 3: Probability distribution of values of vigilance (work orientation coefficient) as a function of duration of flight segments

IMMUNOLOGY

(See also: Operational Medicine: P717)

PAPERS:

P706(16/88) Klusha VYe, Mutseniyentse RK, Svirskis ShV, Zalitis GM, Liyepa IR, Kukayn EM, Andermanis AV, Sile VYa.

Neuroimmune regulating properties of short protein fragments under exposure to immobilization stress.

Byulleten' Eksperimental'noy Biologii i Meditsina.

1987(*): 186-187.

[11 references; 8 in English]

Authors' affiliation: Institute of Organic Synthesis, Latvian Academy of Sciences

Immunology, Humoral Immunity, Endocrinology, Adrenal Gland, Hypothalamus, Striatum

Rats, Male

Short Protein Fragments; Psychology, Immobilization Stress

Abstract: This study investigated the effects of short protein fragments of Immunoglobulin-G (taftsin /Thr-Lys-Pro-Arg-OH/, rigin /Gly-Gln-Pro-Arg-OH/) and structural analogues of IgG fragments (polyarin SKD /Ser-Lys-Asp-OH/ and thymopoietin /Arg--Lys-Asp-Val — Tyr-OH) and substance P (as a control) in the regulation of certain stress-induced neuroendocrine and immunological changes. These peptides were administered intraperitoneally in doses of 100 and 500 ug/kg to male rats 30 before they were exposed to immobilization stress, combined with immersion in water at 22°C for a period of 3 hours. After this period the animals were sacrificed and their hypothalamus, striatum, and adrenal glands isolated for measurement of concentration of noradrenalin and adrenalin. Radioimmune assay was used to determine concentration of corticosterone. Humoral immunity was assessed on the basis of hemagglutination for production of specific antibodies to sheep erythrocytes 7 days after immunization.

Substance P, rigin, taftsin, and thymopoietin completely reversed the decreased concentration of noradrenalin in the hypothalamus typically associated with stress. Polyarin SKD did not do so. These same peptides were effective in the striatum. The most effective correctives for the adrenal gland were substance P and thymopoietin, with SKD inactive. The greatest normalizing effect on adrenalin was produced by substance P and rigin, with SKD producing only a nonsignificant effect. Increased serum corticosterone was completely normalized by substance P, and partially normalized by rigin and thymopoietin, with SKD having no effect. Increased production of antibodies associated with stress was affected only by taftsin and rigin. This data is interpreted as indicating that short native IgG fragments can act as powerful correctors of changes induced by immobilization stress. Particularly effective in this regard are rigin and thymopoietin (in addition to substance P) which normalize substantial effects of stress in the adrenergic system of the brain and adrenal gland (evidently due to their capacity to liberate monoamines) as well as the level of corticosterone. In addition, taftsin and rigin surpass substance P in fully normalizing the humoral immune response to stress.

IMMUNOLOGY

P707(16/88) Pershin BB, Yemel'yanov BA, Sokolov YaA, Kuz'min SN.
Study of the mechanism underlying the phenomenon of disappearance of immunoglobulins under exposure to experimentally induced stress.
Patologicheskaya Fiziologiya i Eksperimental'naya Terapiya.
1987(5): 41-44.
[9 references; 2 in English]

Immunology, Immunoglobulins, Excretion
Mice
Stress, Forced Exercise

Abstract: The goal of this experiment was study of the distribution, binding, and excretion of labeled IgG injected in experimental animals exposed to stress (exercise) varying in intensity and duration. A total of 180 mice were used as subjects. The experimental group was compelled to swim for 2 hours twice a day (with a 2-hour interval) over a period of 5 days. Both experimental and control animals were injected intraperitoneally with radioactively labelled ^{125}I -IgG. Control animals were left alone at this point, while experimental animals were compelled to exercise 30 minutes after injection. At various intervals starting at 2 hours and terminating 5 days after the injection, 5 animals from each group were sacrificed and their blood, liver, spleen, kidneys, lungs, and bone marrow studied. Radioactivity was examined in serum and cells, as well as whole blood. Radioactivity was also measured in the water in which animals had been swimming. Blood was also analyzed to measure the titers of normal antibodies to staphylococcus antigens and tetanus toxins in passive hemagglutination response with the appropriate diagnosticum.

Both control and experimental groups showed a tendency for the activity of the label to decrease over the observation period in the organs studied, with highest level noted in the liver. Radioactivity peaked after 6 hours in blood serum in both groups, but in whole blood this peak occurred only in the experimental group. Blood cells in experimental animals showed a radioactivity level 5 times that of control after the 6-hour period, with smaller peaks after each exercise session. Radioactivity in the swimming water also peaked after the second 2-hour session, i.e., after 6 hours. Physical exercise was associated with decreased immunological parameters at various times in the experiment. Greatest decreases occurred at 2, 50, and 54 hours for IgG in blood serum; 6, 52 and 120 hours for staphylococcus antibodies; and at 6, 54, and 120 hours for tetanus antibodies. Lowest levels occurred directly after exercise sessions. In individual subjects, IgG and antibodies were completely absent at these periods. The authors consider the increased excretion of immunoglobulins into the environment (water) during and after exercise (stress) to be an important finding.

Table 1: Distribution of ^{125}I -IgG in blood of mice exposed to physical exercise

Table 2: Changes in concentration of IgG and titers of normal antibodies in blood serum of mice exposed to physical exercise

IMMUNOLOGY

P742(16/88) Konstantinova IV.

Problems of space immunology.

In: Gazenko OG (editor).

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**].

Moscow: Nauka; 1986.

See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.

Pages: 348-349.

Immunology

Humans, Theoretical Article

Space Flight Factors, Countermeasures

Abstract: Research conducted over the last two decades has demonstrated the influence of space flight factors on the human immune system. Results of this research had defined the main problem to be the development and utilization during space flight of highly effective countermeasures to disrupted human immune response. To achieve this goal, a number of subgoals must be reached: 1) develop new methods for diagnosing immune status of cosmonauts during flight; 2) investigate the significance of vestigial reactions for immune response on repeated space flights; 3) study and test a number of new biologically active substances for correcting immune disorders; 4) develop a system of prophylactic measures, including those specifically directed at immune response, to prevent disease on board spacecraft.

If our earlier hypothesis, proposing that immune system disorders in space flight are associated with changes in calcium metabolism, proves correct, then one goal of space immunology will be to develop means and methods affecting (through mediation by several immunological mechanisms) certain components of the regulation of calcium metabolism in bone tissue.

Solution of the problems listed requires use of qualitatively new methodological approaches and of the latest discoveries in modern molecular and cellular immunology. First and foremost, we are referring to: a) use of trigger molecules, activating T-amplifiers; b) use of the major lymphokine of T-amplifiers -- interleukin-2; c) use of humoral mediators (natural and synthetic) to activate cells producing natural resistance (normal killers and others); d) use of T-suppressor factors and antibodies against them; e) use of hybrids and their products -- monoclonal antibodies and lymphokines -- for diagnostic and therapeutic purposes.

LIFE SUPPORT SYSTEMS
(See also: Space Biology P732)

PAPERS:

P725(16/88) Fofanov VI.

Prospects and developmental trends in space biology.

In: Gazenko OG (editor).

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**].

Moscow: Nauka; 1986.

See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.

Pages: 151-152.

Life Support Systems, CELSS

Humans

Theoretical Article, Future Research Trends

Abstract: Because of the increasing periods of time humans are spending in space, greater attention is being devoted to the effects of humans on the environment and vice versa. On the basis of the work of V.I. Vernadskiy and other scientists, we believe that human vital activity during long periods of time away from the Earth will be supported by systems based on currently existing general biological concepts concerning human anthropoecology. Modern ideas concerning human life support systems for long-term sojourns postulate an LSS capable of forming a living environment completely adequate to human needs (OG Gazenko, YeYA Shepelev, 1972). However, we cannot exclude the possibility and, at times, the necessity of introducing compensatory physical-chemical systems and aggregates into the LSS.

In our consideration of human LSS (ecological systems) for long-term sojourns in space, we must remember that it is hardly necessary to recreate "life in all its variety and total biomass" (NV Timoveyev-Resovskiy) in a spacecraft or on a planetary station. The following ecological principles relating to the functioning of a biological environment should guide the development of a human LSS:

-- The system must contain a quantity of living organisms sufficient to support circulation of substances in the system with minimal formation of "stagnant substances" (VI Vernadskiy, 1967);

-- Autotrophic organisms, the prime producers, are an obligatory component of a human LSS;

-- The "stagnant substances" which are formed should be used for growing organisms useful to support humans;

The following are directions for further research:

-- When space greenhouses are created, it is essential to raise the density of the green cover of the surfaces used. This will make it possible to increase the efficiency of the plants being grown;

LIFE SUPPORT SYSTEMS

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-- Plants should be selected for their capacity to absorb energy;

-- To increase productivity, it is essential that we consider the genetic properties of animals and plants when we select them for inclusion a LSS;

-- We should consider the compatibility of plants and animals included in the LSS, both from the standpoint of their evolutionary development and their capacity to adapt to each other. This will make it possible to create a real community.

-- It is essential that we continue to study the effects of space flight factors and environmental living conditions on autotrophic and heterotrophic organisms, which are components of the LSSs for autonomous living quarters.

One promising future trend involves continuing our research on the biological value of products produced by components of a LSS. These products may contain large organic molecules -- proteins, fats, and carbohydrates, which may be useful to humans.

LIFE SUPPORT SYSTEMS

P731(16/88) Savina VP, Vytchikova LN, Mukhamediyeva LN, Rokhlenko KD.
Microclimate conditions during the flight of Salyut-7.

In: Gazenko OG (editor).

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986].

Moscow: Nauka; 1986.

See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.

Pages: 254-255.

Life Support System, Microclimate; Human Performance, Work Capacity
Humans
Space Flight, Salyut-7

Abstract: The increased use of hermetically sealed living spaces in the economy has lent practical importance to the hygienic aspects of the formation of living environments.

As is well-known, stress on the thermoregulatory processes, and oscillations in total and partial pressure of oxygen and carbon dioxide exceeding the limits of the standard hygienic norms favor the development of asthenic states and decrease in human work capacity. Hygienic monitoring of the microclimate of the Salyut-7 manned space station made it possible to rectify the performance level of the life support systems and also to evaluate their biological effects on the general state and work capacity of crewmembers.

An apparatus was used on board the Salyut-7 to measure total air pressure, partial oxygen and carbon dioxide pressures, and temperature and humidity of the station atmosphere every 1.5 hours. Throughout the entire period the station was in operation, microclimate conditions were optimal for maintaining work capacity of crewmembers. At the same time, analysis of daily microclimate parameters (temperature, humidity, partial oxygen and carbon dioxide pressure, total pressure) allowed us to identify a number of factors actively influencing the thermal properties and gaseous composition of the medium. It was established that performance of a number of technological experiments, operation of light sources, and increased numbers of crewmembers generated additional heat. Air temperature increased by 2-3°C of the normal mean daily levels, without, however, exceeding the boundaries of the thermoneutral zone. Fluctuation of total pressure, partial oxygen and carbon dioxide pressure, was generally smooth and did not exceed standards for living quarters.

Thus, the results of the research performed indicated that microclimate conditions on the Salyut-7 were optimum throughout the flight and supported crewmember work capacity.

MAN-MACHINE SYSTEMS
(See also: Bionics M121)

MONOGRAPH:

M120(16/88) Akhutin VM, Nefedov VP, Sakharov MP, et al.
Inzhenarnaya fiziologiya i modelirovaniye sistem organizma [**Engineering physiology and modeling physiological systems**].
Novosibirsk: Nauka; 1987.
Affiliation: USSR Academy of Sciences, Siberian Division, Institute of Biosphysics; Institute for Problems of Control

KEY WORDS: Man-Machine Systems, Engineering Physiology, Operational Medicine, Mathematical Modeling, Cardiovascular and Respiratory Systems, Metabolism, Habitability and Environmental Effects

Annotation: This monograph is devoted to a new method for analyzing biological systems functioning in a high technology environment. It discusses restoration of physiological functioning using biotechnological systems (computer-aided treatment, artificial organs), and protecting physiological functions from the effects of the environment. Emphasis is placed on modeling the interaction between physiological systems and the technological environment.

This book is intended for scientists the natural and technological sciences -- biophysicists, biologists, physiologists, engineers, systems theory specialists, and physicians working with or interested in processes for controlling and modeling physiological functions.

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MATHEMATICAL MODELING

(See also: Bionics M121; Biospherics P619; Man-Machine Systems M120)

PAPERS:

P701(16/88)* Kondrachuk AV, Sirenko SP.

A two-dimensional statistical model of the otolith.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(6):70-76; 1987.

[14 references; 9 in English]

See: Abstract P668 (Neurophysiology) in Digest Issue 15.

Mathematical Modeling, Statistical

Humans

Neurophysiology, Otolith Membrane, Centripetal Force, Gravity

Abstract: This work offers a mathematical model of the otolith membrane in the form of a two-dimensional elastic plate attached to the maculae at the edges and similar in shape to the actual otolith. A distinguishing feature of the model is its distributed parameters. The statistical behavior of the endolith-otolith membrane system in response to centrifugal force and gravity is derived. Predictions of the model are compared with experimental data. The authors demonstrated that, even when the membrane is homogeneous, different portions of the otolith differ in the deformations they undergo, as a function of membrane configuration and orientation with respect to the force vector.

Figure 1: Otolith structure

Figure 2: Picture of the morphological polarity of the otolith

Figure 3: Projection of displacement U of various point on the otolith membrane as a function of direction of inertial force

P739(16/88) Sakovich VA.

Mathematical modeling in developing standards for the radiation safety of space flights.

In: Gizenko OG (editor).

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986].

Moscow: Nauka; 1986.

See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.

Pages: 322.

Mathematical Modeling, Probability; Hematology, Hemopoiesis
Humans, Cosmonauts
Radiobiology, Radiation Safety Standards, Space Flight, Long-Term

Abstract: To support a set of standards for radiation safety on space flights in order to provide a theoretical basis for the document "Safety standards for flights up to three years" from the standpoint of radiation risk, the author developed a mathematical formalism to provide a probability-based description of radiation conditions on space flights, changes in survival rate in radiobiological experiments, and criteria of radiation safety. It was demonstrated that a model of time of death due to radiation could be constructed if it was accepted that exposure to radiation, in addition to the radiation effects directly associated with probability of death at each moment in time, places a stress on the body, which leads to an exponential increase in rate of death with age. The dynamics of this additional stress under an arbitrary radiation schedule are described by a model of effective dose rate. This model is based on a picture of damage to the hemopoietic system, but it is clear that the additional radiation stress must also include deviations from the norm of parameters indicative of the state of other physiological systems associated with radiation effects. This is how it is planned to compute the spatial nonuniformity of tissue dose in the standard which is to be developed in 1986-1990. The published standards, "A method for computing radiation risk," "A model of the generalized radiobiological effect," as well as "Quality coefficient as a function of linear energy" (planned for 1986-1990), will make it possible to compute radiation risk for an arbitrary spatial-temporal dose distribution for ionizing radiation of mixed composition, and to compare it with the values established by the "Safety standards for flights up to three years in duration," which is essential for the design and functioning of systems supporting radiation safety of space flights.

METABOLISM

(See also: Body Fluids P743; Enzymology P704; Man-Machine Systems M120; Nutrition P740)

PAPERS:

P693(16/88)* Zezerov AYe, Ivanovna SM, Ushakov AS.

Lipid peroxidation in tissues of rats exposed to hypokinesia with head-down tilt, physical exercise, and immobilization stress.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(6):39-43; 1987.

[33 references; 8 in English]

Metabolism, Lipid Peroxidation, Musculoskeletal System

Rats

Hypokinesia with Head-Down Tilt, Physical Exercise, Psychology,
Immobilization Stress

Abstract: Subjects in this experiment were 80 male Wistar rats divided into 7 groups: group 1 - control; 2 - hypokinesia, 3 days; 3 - hypokinesia, 60 days; 4 - control + physical exercise; 5 - hypokinesia, 60 days + physical exercise; 6 - control + stress, 7- hypokinesia, 30 days + stress. Hypokinesia with head-down tilt was achieved by placing rats in immobilization cages with head-down tilt of -15° . After 60 days of hypokinesia animals in groups 4 and 5 were forced to swim in water at 30°C to the point of complete exhaustion. Animals in groups 6 and 7 were immobilized on their stomachs on a special platform for 2 hours. Blood plasma was obtained from sacrificed animals and preparations were made of tissues of the liver, heart, and posterior muscles of the calves. Blood and tissue samples were frozen and lipids isolated. Lipid concentration was determined gravimetrically. Analysis of endogenous lipid peroxidation products was performed using polarography.

Limitation of movement activated processes of free-radical lipid peroxidation in the subjects, as evidenced by accumulation of peroxidation products in the tissues studied after both 3 and 60 days of hypokinesia. Although peroxidation products were lower in concentration after 60 days of hypokinesia, this level was still elevated compared to baseline. The most pronounced changes occurred in the skeletal musculature, while the liver was least affected. Accumulation of lipids in the blood was correlated with levels in the skeletal muscles and myocardia, suggesting that plasma lipids are a good indicator of activity of free-radical peroxidation processes in the tissues. Maximal physical exercise had virtually no effect on level of lipid peroxidation products in the myocardium, but increased their levels in the muscles. Combination of hypokinesia and exercise led to activation of endogenous products of lipid peroxidation in the myocardium and especially the skeletal muscles. Indeed, peroxidation products were more highly concentrated in muscles after exercise and hypokinesia than after hypokinesia alone. Similarly, combined hypokinesia and immobilization stress had a synergistic effect. Under these conditions the highest concentration of lipid peroxides occurred in the skeletal muscles.

The authors conclude that the three extreme factors studied had similar activating effects on processes of free-radical lipid peroxidation in the skeletal muscles. Metabolism of lipid peroxides in the myocardium was less

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sensitive to changes in motor activity, but quite sensitive to short-term stress. Combinations of some of these factors led to marked synergistic effects, including sharp increases in levels of lipid peroxidation. These results are interpreted as suggesting that use of strenuous physical exercise and/or other stressors are contraindicated after long-term restriction of motor activity.

Figure 1: Effects of intense physical exertion on level of lipid peroxidation in animal tissue.

Figure 2: Effects of immobilization stress on lipid peroxidation products in hypokinetic rats.

BR12(16/88)* Demin NN.

Review of: Tigranyan RA. [Metabolicheskiy aspekt problemy stresse v kosmicheskoy polete [Metabolic aspects of the problem of stress in space flight], Moscow: Nauka, 1985, 224 pages.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(6):95; 1987.

KEY WORDS: Metabolism, Psychology, Stress, Immobilization, Biochemical Processes, Space Flight, Cosmos-1129, Adaptation, Neurophysiology, Rats, Hypokinesia, Neurophysiology, Endocrinology, Sympathetic-adrenal System, Pharmacological Countermeasures, Radiobiology, Artificial Gravity, Centrifugation

Review: Although there is an enormous amount of literature devoted to the state of stress, detailed study of the biochemical mechanisms of the stress response is in its nascency. In particular, little has been learned about the metabolic shifts in the nervous system occurring in response to stress, including adaptive phenomena. As for the metabolic aspects of the stress response to space flight factors, particularly weightlessness, the monograph being reviewed is the first to address this theoretically and operationally important issue.

This fundamental work by the eminent biochemist, R.A. Tigranyan, presents a detailed overview of the results of 12 years of research studies, performed (on rats) by the author himself and his colleagues, and in collaboration with the Czechoslovak scientists R. Kvetnyanski and L. Makho. Additional participants in the flight experiments were scientists from the laboratory of functional neurochemistry of the I.P. Pavlov Institute of Physiology of the Soviet Academy of Sciences.

Results of ground-based studies of such states as hypokinesia, repeated immobilization, rotation in a drum and emotional stress, served as a basis for the comparative analysis of the author's experimental data. The information thus obtained is included in chapters I and II. Focusing on biochemical parameters reflecting activity of the sympathetic-adrenal system and on the concentration of opioid peptides and polyamines in the central nervous system, researchers also studied certain lipid metabolism parameters, concentrations of DNA, RNA, and the thiolic groups; activity of choline esterase and a number of metabolic enzymes. Particularly noteworthy and of possible general biological, as well as practical significance, is the data suggesting that premedication with phenazepam [7-Bromine-5-(ortho-chlorphenol)-2,3 dehydro-1H-1,4-benzodiazepin-2-on) can help prevent a number of the neurochemical disorders engendered by immobilization, and prevent the neurochemical shifts occurring in response to sleep deprivation.

The entire body of new data is unquestionably a significant contribution to the study of biochemical and endocrinological correlates of stress. The central portion of the monograph (chapters III-VII) is devoted to a detailed discussion of the results of study of biochemical parameters in response to stress in experimental animals on 18.5-22 day space flights performed from 1973-1979 on five Cosmos biosatellites. On one satellite, animals were exposed during flight to the effects of ionizing radiation, on another a group of rats were exposed to conditions simulating earth's gravity (through constant centrifugation). A portion of the animals flying on the Cosmos-1129 biosatellite were subjected to immobilization stress daily for 150

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minutes over 6 days. Control groups included a vivarium group and animals maintained on Earth under conditions identical to those of the flight group (synchronous control). The data obtained from comparisons of the flight to the synchronous group make it possible to separate out the effects of weightlessness per se.

This monograph ends with a substantive "Conclusion" in which the author summarizes and critically discusses the extensive range of experimental material presented in previous chapters. In general, despite the fragmentation of this material (resulting from a variety of problems beyond the researchers' control), as well as some contradictory results which make interpretation difficult, the author credibly justifies his idea that after space flight, animals display signs of a combination of acute stress caused by reentry and elements of a weaker state of chronic stress engendered by space flight itself. Stress factors arising during biosatellite flights evidently include relatively long periods of weightlessness, hypokinesia and an impoverished sensory environment. As has already been noted, the effects of the latter two factors may be identified by studying effects in the synchronous control group.

In summary, Professor R.A. Tigranyan's monograph contains a great deal of unique data, obtained as a result of unique experiments in weightlessness on biosatellites. This has made an essential contribution to the development of space biology.

The monograph includes illustrations of the apparatus used, a large number of graphs of specific experimental data, and an extensive list of cited references.

This book is intended for biochemists, physiologists, and pathophysiologicalists interested in the problem of stress, and also specialists working in the area of space biology and medicine.

MICROBIOLOGY: See Botany P737; Gravitational Biology P735

MUSCULOSKELETAL SYSTEM

(See also: Gravitational Biology P718; Metabolism P693;
Musculoskeletal System P726)

PAPERS:

P691(16/88)* Il'ina-Kakuyeva YeI.

[Study of] skeletal muscles of rats after a short-term space flight on the Cosmos-1667 biosatellite.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(6):31-35; 1987.

[13 references; 8 in English]

Musculoskeletal System, Skeletal Muscles, Soleus, Biceps, Quadriceps,

Gastrocnemius

Rats, Males

Space Flight, Cosmos-1667

Abstract: This experiment studied the soleus, gastrocnemius, quadriceps, and biceps muscles of Wistar-SPF male rats flown for 7 days on the Cosmos-1667 biosatellite and a like number of vivarium controls. The animals were sacrificed 4-8 hours after reentry. Muscles were fixed and cross-sections prepared. Staining was used to reveal erythrocytes in functioning capillaries and the number of erythrocytes in 200 muscle fibers was counted. Histochemical analyses included: comparative analyses of the concentration of glycogen, phospholipids, activity of phosphorylases, succinate dehydrogenase and alpha-glycerophosphate not bound to NAD in muscle fibers. Muscle fiber type was determined by morphometry and measurement of ATPase myosine activity. Three types of fiber were identified on the basis of size and activity of oxidative enzymes: type I - red, fine with high enzyme activity; type II - white, large with low enzyme activity; III - intermediate in size, color, and enzyme activity. Preincubation in Ca-formol made it possible to further subdivide muscle fiber types. Type I had two subtypes, one of which (A) showed very high ATPase activity, while in the other (B) such activity was virtually absent. Type II fibers showed moderate ATPase activity. Type III fibers varied in size, with A being larger and B smaller. The sixth type of fiber, large and with no ATPase activity, occurred only in the quadriceps. Tonic soleus muscles contained two types of fibers - those with high and and those with low ATPase activity. Muscle fiber cross sectional area was determined gravimetrically.

Body weight of flight rats did not differ from that of controls. Effects of flight on muscle weight varied depending on muscle. Soleus muscle was most reduced (22.7%); mass of gastrocnemius and biceps decreased by 10.7% and 12.3% respectively; while quadriceps mass was unchanged. Morphometry showed that atrophy was one reason for muscle weight loss. In the gastrocnemius and biceps only one type of fiber, type I B, showed atrophy. The soleus muscle showed signs not only of atrophy, but of dystrophy, manifested by fibers with aberrant reaction products. Distribution of fiber types did not differ in flight and control animals. All muscles (even fine fibers with high oxidative metabolism) of flight animals showed elevated glycogen content accompanied by increased phosphorylase activity. In addition, all muscles showed decreased succinate dehydrogenase activity, and

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the soleus displayed increased activity of alpha-glycerophosphate not bound with NAD. No differences were found in number of functioning capillaries in any of the muscles studied. The authors conclude that this study shows that the process of muscle atrophy begins in rats during the acute period of adaptation to weightlessness, which in the gastrocnemius and biceps affects mainly red fibers with high oxidative metabolism and low ATPase activity. Atrophy of soleus muscles is accompanied by dystrophic changes. These phenomena occur in concert with metabolic changes marked by an accumulation of glycogen in muscle fibers.

Table 1: Area of cross section of muscle fibers

Muscle	Fiber Type	Vivarium Control	Flight
Soleus	Red	3.48	2.98*
	Intermediate	4.27	3.52*
Gastrocnemius	White	5.06	4.59
	Red A	2.27	1.98
	Red B	2.56	2.05*
	Intermediate A	3.18	3.01
	Intermediate B	2.48	2.26
Quadriceps	White	6.18	6.57
	Red A	1.69	1.63
	Red B	1.83	1.78
	Intermediate A	3.15	3.26
	Intermediate B	2.29	2.49
Biceps	White	3.96	3.58
	Red A	1.42	1.33
	Red B	1.41	1.19*
	Intermediate A	2.43	2.29
	Intermediate B	2.07	2.06

* differences between flight and control groups statistically significant.

Table 2: Number of functioning capillaries per 200 muscle fibers

Muscle	Vivarium Control	Flight
Soleus	156.3	149.5
Gastrocnemius	119.5	113.4
Quadriceps	133.5	130.1
Biceps	115.4	109.5

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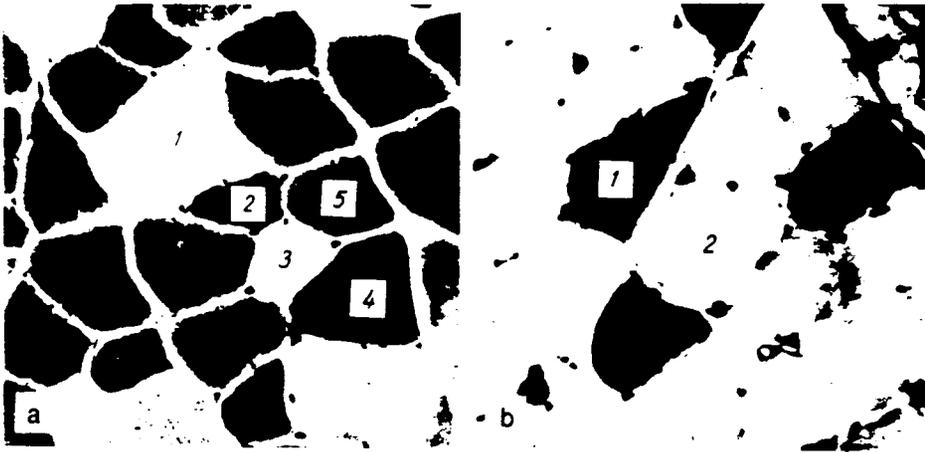


Figure 1: Activity of ATPase myosin in muscle fibers of various types
a - gastrocnemius m. Fiber types: 1 - white; 2 - red A; 3 - red B;
4 - intermediate A; 5 - intermediate B; b - soleus m.; Fiber types:
1 - red A; 2 - intermediate

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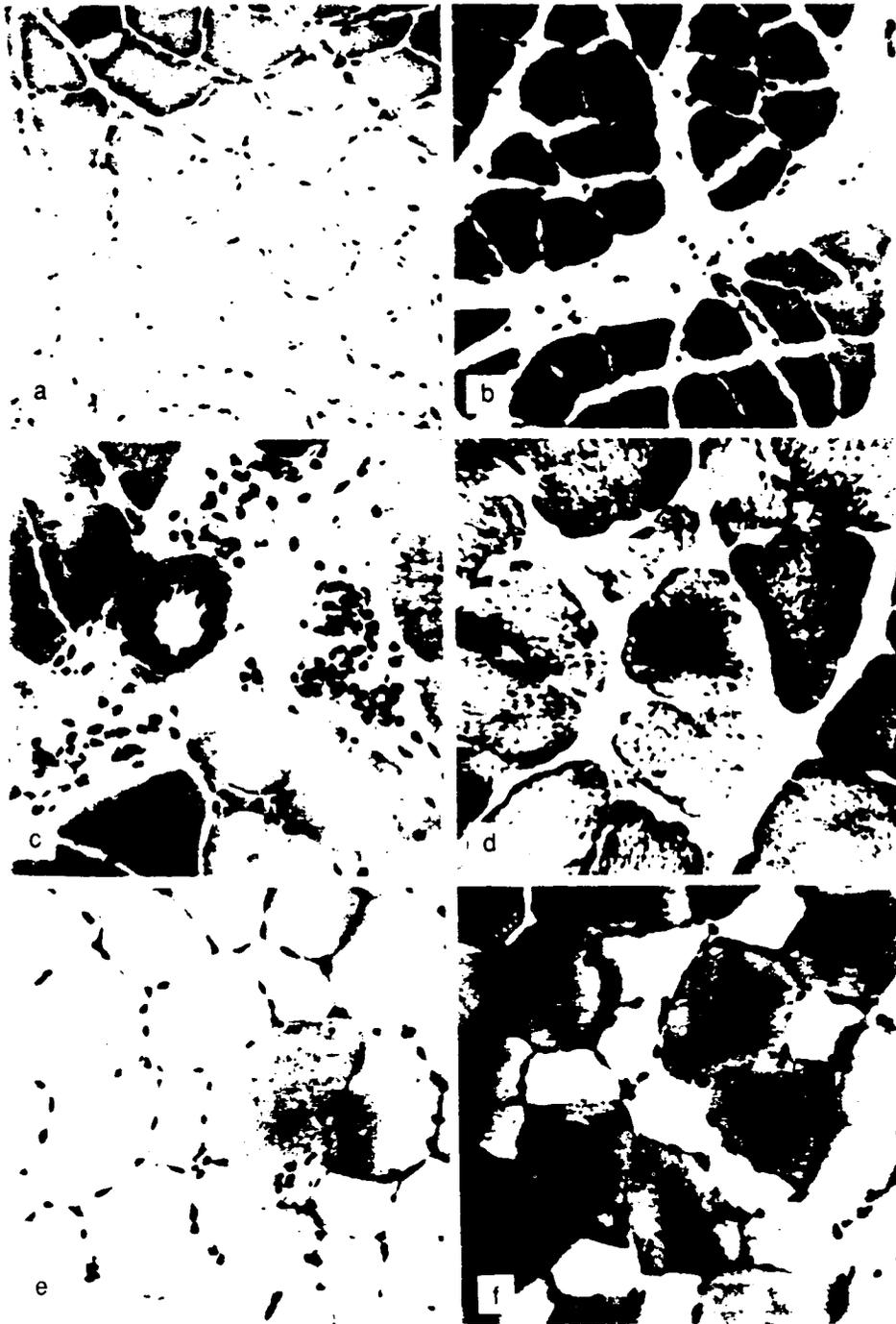


Figure 2: Soleus m.

a - control; b - widening of the interlayer?? of the endomysium indicating development of muscle edema. Ob. 0, ok. 10; c - proliferation of connective tissue cells around the vessels. Stained with hematoxylin and eosin; d - target?-fibers surrounded by atrophied fibers with aberrant distribution of diphormazan when succinate dehydrogenase measured??; e - concentration of glycogen in the gastrocnemius muscle of a control animal; f - experimental animal.

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P692(16/88)* Kaplanskiy AS, Sakharova ZF, Il'ina-Kakuyeva YeI, Durnova GN.
Morphological study of early changes in the bones of rats exposed to simulations of weightlessness.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(6):36-39; 1987.

[13 references; 5 in English]

Note: See abstract P647 (Musculoskeletal System) in Digest issue 15.

Musculoskeletal System, Bones, Tibia, Lumbar Vertebrae

Rats, Male

Weightlessness Simulation, Immobilization; Psychology, Stress; Tail Suspension

Abstract: Analyses were performed on the tibia and lumbar vertebrae of 38 male Wistar rats. There were two experimental groups: in the hypokinesia group (N=10) animals were maintained for 7 days in immobilization cages; in the suspension group (N=8) animals were suspended by the tail for the same period. In addition, there was a vivarium control (N=9) and 10 rats were sacrificed before the beginning of the experiment as a baseline control. After the experimental period animals were weighed and sacrificed and their tibia and lumbar vertebrae isolated, cleaned, fixed, and decalcified. The proximal portion of the tibia, a segment of the diaphysis, and the vertebrae were dehydrated, sectioned and stained for analysis. An ocular micrometer was used to measure the thickness of the epiphysis cartilage of the growth layer and the width of the zone of the primary spongiosa in sections of the proximal tibia and lumbar vertebrae. The density of the primary and secondary spongiosa was measured using a grid, which was also used to count the number of Haversian canals in the compact substance of the tibial diaphysis. Number of osteoblasts and osteoclasts in the primary spongiosa zone in the lumbar vertebrae and tibial metaphysis were computed for 20 and 50-70 visual fields, respectively. Area of the compact substance, marrow cavities and diaphyses of the tibia were determined morphometrically.

No differences were found between the proximal tibia of baseline and vivarium groups. The proximal tibia of animals undergoing hypokinesia or tail suspension displayed statistically significant narrowing of the growth layer and primary spongiosa. There was also a decrease in the density of the primary and secondary spongiosa and an increase in the number of osteoclasts, due primarily to a greater number of mono- and binucleate forms. No changes in osteoblast number occurred in any of the groups, however the hypokinesia and suspension groups displayed an increase in non-active cells or cells with signs of dystrophic damage. No significant changes were found in the diaphysis of experimental animals. The lumbar vertebrae of both experimental groups showed decreased thickness of the growth layer and primary spongiosa zone. Only animals undergoing hypokinesia displayed decreased primary and secondary spongiosa density in the vertebrae. Both experimental treatments led to qualitative changes in the osteoblast populations analogous to those in the tibia. Vertebrae of hypokinetic animals also contained a diminished number of osteoblasts. No changes in numbers of osteoclasts were noted.

The data obtained show that despite the relative brevity of the experiment, signs of osteoporosis arose in the spongy bone in response to both weightlessness models. The question of whether osteoporosis under these conditions results only from inhibited bone growth or additionally from increased resorption remains open, since osteoclast number increased only in

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the spongiosa of the tibia and not in the vertebrae. The similarity of the changes observed in the bones of rats undergoing the two treatments, as well as the relatively rapid occurrence of these changes, suggests that an acute stress response plays a role in the early effects of both weightlessness analogues. It should also be noted that changes in the spongiosa are less pronounced in response to tail suspension than to immobilization which agrees with data suggesting that the latter treatment is considerably more stressful.

Table 1: Results of morphometric studies of the growth layer and spongiosa of the proximal metaphysis of tibia and lumbar vertebrae in rats

Group	Growth layer width, um	Primary spongiosa width, um	Primary spongiosa density, %	Secondary spongiosa density, %	Number osteoblasts in field	Number osteoclasts in field
Metaphysis of tibia						
Baseline control	427	543	47.3	22.5	40.0	1.54
Vivarium control	451	580	47.0	25.1	36.0	1.80
7-day hypokinesia	304*	334*	35.9*	16.4*	39.7	2.41*
7-day suspension	301*	334*	36.6*	15.9*	39.8	2.12*
Lumbar vertebrae						
Baseline control	136	180	41.4	22.7	16.0	2.3
Vivarium control	131	190	39.0	22.6	16.5	2.8**
7-day hypokinesia	110*	110*	24.6*	18.2*	12.2*	2.7
7-day suspension	120*	110*	33.6	20.0	13.1	2.4

* difference between experimental and vivarium control statistically significant (p<0.05)

** difference between vivarium and baseline controls statistically significant

Table 2: Results of morphometric analysis of diaphysis of tibia bones of rats

Group	Area of compact substance	Area of marrow cavity	Number of Haversian canals	Area of Haversian canals	Area of osseous lacunae
Baseline control	0.42	0.46	125.9	0.035	0.019
Vivarium control	0.41	0.52	137.1	0.037	0.021
7-day hypokinesia	0.41	0.54	146.0	0.036	0.021
7-day suspension	0.43	0.43	163.5	0.038	0.023

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P696(16/88)* Belkaniya GS, Kurochkin YuN, Rakhmanov AS, Simavonyan KV, Dartsmeliya VA, Demin AN, Filenko VYe.

Morphological concomitants of adaptation to an upright posture and walking erect in monkeys.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(6):50-54; 1987.

[15 references; 4 in English]

Musculoskeletal System, Morphological Changes, Bone Minerals; Adaptation, Postural

Monkeys, Rhesus Macaques

Gravitational Biology, Upright Posture, Walking Erect

Abstract: The goal of this study was to establish morphological concomitants of postural adaptation of the musculoskeletal system to gravity in monkeys compelled to stand and walk upright. The experimental group consisted of 6 male rhesus macaque monkeys which through some unspecified (apparently restraint of upper limbs) experimental procedure were compelled to function as bipeds for a period of 2 years. A control group of 10 comparable monkeys was used. Measurements of the animals' bodies were made using specially adapted anthropometric instruments and skeletons were X-rayed. Concentration of bone minerals in the portions of the animals' skeletons was determined using gamma-photon absorptiometry. Mineral densities of the tibia and fibula bones at points 50% and 75% of its length, of the proximal portion of the metatarsus, and radius and ulna (at 15% and 50% of their length) bones were determined for each monkey.

During the first few months of bipedalism the monkeys developed the characteristic stance for vertical posture, involving straightening of the trunk and lower limbs. These characteristics were even more marked during walking and running. The most pronounced difference between control and experimental animals revealed by X-rays involved the geometry of the spine. Lordosis increased substantially in the bipedal animals; visual impressions of lordosis were confirmed by mathematical analysis of the curvature of the spine. The index used for lordosis increased from 1.5 to 4.5 after 8 months of bipedalism and to 10.0 after 11-12 months. Differences between control and bipedal animals were apparent both in position required for X-ray and while standing in an unstricted position. Differences were also noted in the legs. No degenerative changes were noted in the spine even after 2 years of bipedalism in monkeys, unlike rats. Bipedal animals displayed hypertrophy of the muscles of the pelvis and legs, with a 22 and 12% increase in muscle mass of the thighs and calves, respectively. Changes were more pronounced in the antigravity muscles. Some hypotrophy was noted in the muscle of the shoulder girdle, but muscular development in the forearm was no different from that of controls. Mineral density of bone tissue increased after a year of bipedalism by 38% for the tibia and 14% for the fibula. Mineral density of the proximal third of the tibia increased less than density of the medial third. Bipedalism also led to disappearance of the lateral asymmetry in density (right leg less dense) found in control animals. Mineral density of the metatarsus also increased significantly, while mineral density of the radius and ulna did not differ from control values.

The authors conclude that their data provides additional information about

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the role of gravity in determining the form of the bodies of animals and confirms the utility of using artificially bipedalized monkeys as a research model in gravitational biology.

Table: Mineral density of bone tissue in control and biped monkeys

Figure: Major characteristics of postural adaptation of the musculoskeletal system in monkeys with experimentally created bipedalism

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P714(16/88) Glushko TA, Gusakova VA, Malova NG.

Changes in intervertebral disk tissue in response to hypokinesia in rats varying in age

Arkhiv Anatomii, Gistologii, i Embriologii.

XCIII(12): 50-55; 1987.

[7 references; 2 in English]

Authors' affiliation: Central Scientific Research Laboratory, Ukrainian Institute of Physician Training

Musculoskeletal System, Intervertebral Disc
Rats, Developmental Biology, Age Differences
Hypokinesia, Immobilization, Short- and Long-Term

Abstract: A total of 80 male Wistar rats, aged 3 or 12 months, were confined in immobilization cages for 7 or 30 days (20 rats of each age per condition). A vivarium control group (n=20) was used for each age group. After sacrifice of the subjects, the vertebral segments were isolated from the lumbar region, fixed, dehydrated, and stained. Polarization-optical analysis was used to obtain information about the orientational sequence and interrelationships of the macromolecules of collagen proteins and glycosamines. The refraction parameter used was the mean of three measurements: in the outer, middle, and inner (adjacent to the pulpous nuclei) zones of the fibrous ring of the intervertebral disk.

For both age groups, hypokinesia was associated with changes in all portions of the vertebral segment, to an extent determined by treatment duration. After 7 days of hypokinesia the younger animals showed inhomogeneous distribution of cellular components in the growth layer due to appearance of small acellular homogeneous areas. The vertebral pulp zone was wider than that of control animals. The experimental group of older animals displayed thinning of the bone trabeculae in the body of the vertebrae, accompanied by broadening of the bone marrow cavities. In the cartilage proliferation zone of the growth layer, cellular organization was disrupted. There were isogenous groups of cartilaginous cells in the zone of the intervertebral disk on the boundary between the nucleus pulposus and the fibrous ring. The area between the nucleus pulposus and the epiphyseal layer was filled with spongy bone. The zone of the pulpous nucleus was broadened.

After 30 days of hypokinesia the trabeculae in the vertebral bodies were thinned in both the younger and older animals. The zone occupied by the pulpous nucleus was also somewhat enlarged. In 20% of the animals of both ages there were changes in the structure of the inner portions of the fibrous ring related to destruction in the bundles of collagenous fibers, uneven distribution of cells and the appearance of homogeneous structureless masses. In addition, the fibrous cells of mature rats contained cartilaginous cells with intensely basophilic nuclei among the bundles of cartilaginous fibers. There were extensive areas of cartilaginous tissue containing hypertrophied chondrocytes between the fibrous ring and the zone of proliferating cartilage of the growth layer.

After 7 days of hypokinesia, topo-optical studies showed a significant decrease in the refraction of collagen compared with control level (8% in younger, 12% in older animals). The longer period of hypokinesia resulted in further decrease in collagen refraction, especially in older animals. Refraction of total glycoaminoglycans was within control limits for all

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hypokinesia groups. Refraction of keratan sulfate was higher than control in all groups, particularly in younger animals after the 30-day treatment.

Figure 1: Growth layer of the vertebral body of a 3-month-old rat

Figure 2: Fibrous ring of the intervertebral disk of a 3-month-old rat

Figure 3: Change in the degree of refraction of macromolecules in the fibrous ring of the intervertebral disk in rats after 7 and 30 days of hypokinesia

NEUROPHYSIOLOGY

(See also: Bionics M121; Cardiovascular and Respiratory System: P715; Gravitational Biology: P718; Mathematical Modeling P701; Metabolism: BR12; Operational Medicine P717; Psychology P726; Radiobiology P712)

PAPERS:

P702(16/88)* Davydov BI, Ushakov IB, Fedorov VP.

The combined effects of ionizing radiation and altered gas medium on the central nervous system.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(6):76-83; 1987.

[14 references; 9 in English]

Neurophysiology, Central Nervous System

Dogs

Radiobiology, Gamma Irradiation, Hypoxia, Oxygen Breathing

Abstract: A total of 67 dogs of both sexes served as subjects for this experiment. Several groups of dogs were exposed to head or whole body gamma irradiation in a dose of 5 Gy with dose rate of 4.2 cGy/sec. During irradiation a portion of these animals were compelled to breathe a hypoxic gas medium with 7% (HGM-7) and 10% (HGM-10) oxygen or pure normobaric oxygen. The remaining animals breathed air. Concentration of CO₂ during the experiment did not exceed 0.3%. To investigate the possible role of disruption of the hydration profile of the brain after irradiation the concentration of water in various portions of the subjects' brains was studied by dessication. Portions of the central nervous system studied included: spinal cord and medulla oblongata; pons varoli; peduncle and tectum of the midbrain; cerebellum, anterior and posterior hypothalamus; caudate nucleus; hippocampus; the corpus callosum; and various lobes of the cerebral cortex (archipallium, limbic, frontal, sensorimotor, temporal, parietal, and occipital lobes). Neurohistological, histochemical, electron microscopic, and morphological analyses were also performed. Neural and glial cells were identified. The state of myelin envelopes was evaluated. Concentrations of total protein, RNA, glucosamines, succinate dehydrogenase (SDH), lactate dehydrogenase (LDH), alkali phosphomonoesterase, acid phosphomonoesterase, and chymase were measured. Activity of alkaline phosphomonoesterase, dehydrogenase, and protein were also assessed. Karyometric methods were used to measure the large and small diameters of neurocyte nuclei, and their volume was derived using the ellipsoid rotation formula. The number of neural and glial cells per unit area, and the percentage of cells with reactive and destructive changes were computed, as was the neurocellular index. Electron microscopy was performed on ultrathin sections prepared from the brain.

Most of the reliable changes were noted in the cortex of the brain. There was a gradual and constant increase (over 5 hours) in the extent of hyperhydration in the brain and in the number of structures with increased water content. This increase was more pronounced for head than for whole-body irradiation. Morphological studies revealed signs of reactive, destructive and compensatory responses to both local and whole-body irradiation. Changes were most pronounced in the sensorimotor cortex, and were pronounced for whole-body irradiation. These changes resulted in a significant decrease in the neurocellular index. In the cerebellum,

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changes were first noted 5 hours after irradiation. After head irradiation, these changes were more likely to be destructive than after whole-body. In the thalamus and caudate nucleus, reactive changes were noted after 5 hours only in the head irradiation condition. In addition, more reactive and destructive changes were noted in the hippocampus after head than after whole-body irradiation. No changes were observed in the medulla oblongata. It should be noted that the majority of neural and glial cells did not show morphological changes. No changes were found in the vascular system. Neither stasis in the microcirculatory bed nor bleeding in the brain tissue were noted.

Electron microscopy showed deeper changes than were detected optically. Again, these were more pronounced when only the head was irradiated. Ultrastructural effects were most evident after 5 hours and involved all components of the central nervous system. The most typical change was impoverishment of the ultrastructure (particularly ribosomes) of the neurons and swelling of the mitochondria, cytoplasm nets, and elements of the Golgi apparatus. There were histochemical decreases in activity of the redox enzymes and increased activity of acid phosphomonoesterase. Examples of changes included sites of degeneration and the presence of pyknomorphic cells. After whole-body irradiation these changes were most likely to occur in the sensorimotor cortex and thalamus, and after head irradiation in the sensorimotor cortex and hippocampus. There were an especially large number of synapses with light or focal degeneration. Light degeneration was equally distributed in all parts of the central nervous system while focal degeneration occurred mainly in the thalamus. A series of changes occurred in the blood-brain barrier. However, transport through the capillary wall, as demonstrated by parameters of alkaline phosphomonoesterase activity, was unchanged. Intercellular contacts were unchanged and the basal membrane retained its normal ultrastructure despite isolated signs of destruction. Vacuolization occurred in the cytoplasm. Number of mast cells, identified by reactions to chymase, was diminished. Hypertrophized astrocytary processes were common. Thus, there were a number of changes of which the most notable were damage to synapse architechtonics and the blood-brain barrier; however, none of these were sufficient to affect functioning. The overwhelming majority of interneuronal contacts were normal and the majority of cellular elements did not display major ultrastructural damage, and some signs of assimilative-adaptive response could be found. Activation of the protein synthesis system, as evidenced by changes in the size of the neuronal nucleus in different portions of the brain, was more pronounced after whole-body irradiation. No evidence was found of paired neurons, which many authors consider an expression of compensatory-adaptive processes in response to brain irradiation.

Breathing pure normobaric oxygen had virtually no effect on the hydration profile of the brain after 5 hours. While effects of HGM-10 were not significant, HGM-7 increased hydration. Hyperoxia led to reactive and even destructive changes in the brain, which were statistically significant in the hippocampus. However, the major portion of cells in all structures evinced no morphological changes. Nor did electron microscopy reveal any major effects. There was a significant decrease in lactate dehydrogenase in the hippocampus. The 7% hypoxic mixture caused 40% of the neurocytes in the sensorimotor cortex to show morphological changes causing the neurocellular

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index to decrease substantially. A large number of changes in cellular and vascular elements were discovered in the ultrastructure analysis. These were most pronounced in the limbic cortex and hippocampus and least marked in the brain stem. When subjects breathed HGM-10, synaptic changes were only noted in isolated instances. However HGM-7 was associated with marked light-type degenerative changes in interneuron contacts. Both mixtures were associated with changes in the blood-brain barrier. Thus, altered (hypoxic) gas media used to modify the effects of radiation on the central nervous system can themselves induce a number of changes in the central nervous system.

When combined with irradiation pure oxygen increased and hypoxic mixtures decreased the number of structures showing hyperhydration 5 hours after irradiation. Pure oxygen decreased the number of nerve cells in a unit area in the sensory motor cortex after irradiation, suggesting the late stages of degeneration. Synergies were also found in the cerebellum, hippocampus, caudal nucleus, and thalamus. The ultrastructure study revealed dark and pyknomorphic cells with pronounced astrocytary reaction and neuronophagia. Other degenerative changes were common. However, other parameters showed signs that oxygen attenuated the effects of radiation on the nervous system (less marked swelling of the perivascular astrocytary mufta?? and less edema; improved synapse architectonics, especially in the thalamus and sensorimotor cortex). Breathing of HGM-10 did not alter the effects of radiation on the nervous system. Breathing of HGM-7 did not attenuate the effects of radiation on the nervous system, but even increased them in the sensorimotor cortex and cerebellum, increasing the number of cells with morphological changes. Ultrastructure studies also showed that this mixture worsened the effects of radiation. Synapse architectonics in irradiated animals breathing HGM-7 showed minimal differences from those breathing air. Components of the blood-brain barrier showed stronger effects than occurred after irradiation alone. Hypoxic breathing mixtures appeared to increase vomiting by irradiated animals.

Table 1: Changes in the concentration of total fluid in various structures of the central nervous system in dogs after whole-body or local irradiation

Table 2: Characteristics of changes in the sensorimotor cortex of dogs 5 hours after irradiation in a dose of 5 Gy in an altered gas medium

Table 3: Size of nuclei 5 hours after irradiation of dogs breathing an altered gas mixture

Table 4: Initial response of dogs irradiated in a dosage of 5 Gy while breathing hypoxic gas mixtures

NEUROPHYSIOLOGY

P720(16/88) Kornilova LN, Kasparanskiy RR, Bodo G, Antal P (Last two are Hungarian.)

The effects of weightlessness on vestibular and vestibulo-eye movement responses.

In: Gazenko OG (editor).

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**].

Moscow: Nauka; 1986.

See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.

Pages: 76-77.

Neurophysiology, Vestibular and Eye Movement Responses, Saccadic Movement, Nystagmus, Perception, Visual Humans, Cosmonauts Space Flight, Adaptation

Abstract: Between 1975 and 1985, Soviet scientists gathered a great deal of material related to the phenomenology of sensory, autonomic, and vestibulo-autonomic responses, observed in cosmonauts during the initial period of adaptation to weightlessness and subsequent readaptation to gravity. In addition, some cosmonauts noted problems with visual fixation during head motion or when objects in the field of vision were moving.

For these reasons, beginning in 1979, members of space crews conducted a systematic program of research to study the genesis of these phenomena. The methods and approaches used included specific vestibular and optokinetic stimulation. The "Optokines" program for studying the mechanisms underlying vestibulo-visual and vestibulo-eye movement interaction in weightlessness was an important component of this research. This program encompassed four experiments utilizing the "OKING" device which projected a set of visual stimuli on a television screen according to a variety of schedules. Programs of graded and multidirectional vestibular, foveal and foveoretinal optokinetic stimulation were developed to enable the study of individual parameters of visual tracking, thresholds of the optokinetic reflex, and the nature of compensatory eye movements in response to specific vestibular stimulation.

The research performed under conditions of weightlessness revealed a variety of changes in eye movement function. Destabilization of the eyeball, as reflected in heightened spontaneous eye movement activity of saccadic or smooth following movements, and occasional nystagmic reactions were noted while cosmonauts were at rest.

In weightlessness, the amplitude-frequency curves of the functions of saccadic and smooth following were altered, and reactions were asymmetrical. Smooth following was accompanied by the appearance of additional correcting saccadic movements in the direction of the moving stimulus or nystagmic clusters. In a number of cases the fixating capacity of the eyes was disrupted and there was a marked increase in the variability of saccadic amplitudes. Thresholds of optokinetic nystagmus decreased. There were changes in compensatory eye movements to specific vestibular stimuli and nystagmic reactions occurred which are not observed on Earth.

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The data obtained demonstrates increased excitability of the visual and vestibular systems. Evidence for this includes decreased thresholds for optokinetic as well as vestibular nystagmus. Thus, adaptation to weightlessness is accompanied by adaptive restructuring of the vestibular sensory system, which may be associated with vestibular sensory input from the nonacoustic labyrinth, as well as with input from related systems (visual and proprioceptive). The nature of the phenomena discovered suggest that the greater portion of the changes observed under weightlessness are associated with adaptive functional restructuring at the level of the brain stem.

NEUROPHYSIOLOGY

P721(16/88) Lapayev EV, Vorob'yev OA.

The problem of vestibular physiology in aerospace medicine and prospects for its solution.

In: Gazenko OG (editor).

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986].

Moscow: Nauka; 1986.

See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.

Pages: 85-86.

Neurophysiology, Vestibular Physiology, Motion Sickness; Perception, Spatial Disorientation, Sensory Conflicts; Personnel Selection; Body Fluids Humans, Cosmonauts, Pilots, Theoretical Article
Operational Medicine, Aerospace Medicine, Acceleration, Countermeasures

Abstract: One of the most widespread forms of ecological interaction between humans and the environment during aerospace flight is the constant exposure to specific dynamic factors (angular, linear, Coriolis acceleration and others). Practices in providing medical support for aircraft and space flights testify to the increased urgency and practical significance of understanding vestibular function with respect to the goals of aerospace medicine. Most important among these goals is development of countermeasures for the adverse effects of vestibular disturbances (motion sickness, spatial disorientation) which, in a number of cases, persistently occur in trainees, pilots, and cosmonauts exposed to dynamic flight factors.

An important trend in preventing such disturbances has been preselecting personnel for vestibular tolerance and developing procedures for vestibular preconditioning. At present, the most common method used for this purpose encompasses techniques involving exposure to Coriolis acceleration. However, these techniques do not simulate sensory conflicts and redistribution of body fluids, which are currently considered to be the main cause of motion sickness.

The experimental and theoretical research we have conducted, involving the combined effects of angular, linear, and Coriolis acceleration and optokinetic stimulation, have led us to the hypothesis that one's susceptibility to motion sickness under complex dynamic conditions is proportional to the ratio of the amplitude-phase characteristics of afferent signals from vestibular and extralabyrinthine (visual, proprioceptive and others) structures, which is proposed as a criterion of "level of stimuli conflict" induced by motion under such conditions. Thus, estimation of these ratios would, in all probability, enable a comparative quantitative evaluation of the intensity of stimulation of the sensory systems during vestibulometric tests of aviation or space flight factors as an approach to the solution of practical problems of specific laboratory simulation of the physiological effects of dynamic space flight factors.

Research results have demonstrated that the most effective means of decreasing susceptibility to motion sickness is to stimulate other sensory systems while training the vestibular system. The trainee thus develops increased tolerance for a wider range of dynamic factors. The vestibulo- autonomic and vestibulosensory reactions which were induced

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by passive bending of the trainee in a rotating system were less extreme. This fact emphasizes the important role played by active movements of the head, including tonic cervical reflexes, that induce motion sickness and spatial disorientation under complex dynamic conditions.

Thus, the selection and training of pilots or cosmonauts should include stimulating both labyrinth and extralabyrinth structures, producing sensory conflict between the two sources (i.e, creating the maximum amplitude-phase discrepancies between the two signals). In addition, it would be desirable to develop an individualized approach to measuring the parameters of physical stimuli characteristic of specific space flight factors. Finally, the greatest effect of vestibular training can be achieved by using a set of special physical exercises directed at optimizing the interaction of vestibular and cervical tonic reflexes with respect to dynamic conditions and modeling the air and space flight factors that induce redistribution of body fluids.

NUTRITION

PAPER:

P740(16/88) Balakovskiy MS, Ushakov AS, Pastushkova LKh, Spitsina NYe, Yuzhanskaya MG, Bogdanov NG, Gvozdoval IG, Smirnova AN, Pyatnitskaya IN. **Vitamin status of humans undergoing a 120-day period of hypokinesia with head-down tilt.**

In: Gazenko OG (editor).

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986].

Moscow: Nauka; 1986.

See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.

Pages: 332-333.

Nutrition, Vitamin Status; Metabolism, Adaptation; Enzymology
Humans

Hypokinesia with Head-Down Tilt; Countermeasures, Exercise

Abstract: Exposure of the human body to various extreme factors (including hypokinesia) leads to heterogeneous changes in metabolic processes, causes decreased work capacity in a number of instances, and increases recovery time for the functions of certain physiological systems. For these reasons increasing attention has been focused recently on issues related to the development of measures to facilitate normal metabolism, to retain high physical and mental work capacity, and decrease functional recovery time. One of the ways to address this issue is through optimizing nutrition. It is particularly important to provide the essential nutritional factors, including vitamins. The need to conduct extensive research directed at understanding human vitamin status during prolonged hypokinesia is obvious and urgent both with a view toward solving problems in space medicine, and to increase understanding of a number of issues in public health practice (limited movement, bed rest, etc.)

To evaluate changes in metabolism of vitamins A, B₁, B₂, B₆, B₁₂, B_C, PP, C, D, and E under conditions of a 120-day period of hypokinesia with head-down tilt (-4.5°), we used accepted criteria for indicating vitamin balance within the body: concentration of vitamins in the diet, concentration in the blood, amount of excretion of vitamins or their metabolites with daily urine, level of activity of enzymes with vitamin-containing coenzymes, and characteristics of activation of enzymes by their coenzymes. The experiment used a standard diet monitored for all the basic nutrient substances. Study of parameters indicative of vitamin metabolism performed during a baseline period showed that subjects had a relatively high vitamin level before the experiment. Research performed during hypokinesia with head-down tilt showed some changes in level of vitamins in the subjects. There was a noticeable increase of vitamins with antioxidant response to retinol (and its previtamin carotenin), ascorbic acid, and tocopherol in blood serum.

Parameters of daily renal excretion of thiamine, riboflavin, 4-pyridoxic acid, N₁-methylnicotinamide, data reflecting activity of vitaminized enzymes (transketolases, glutathione reductases, aspartate aminotransferases), and

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characteristics of enzymes activation by their coenzymes (TDF-effect, FAD-effect, PALF-effect) all indicated that water-soluble vitamins are concentrated in biological body fluids during this period. Significant changes in blood concentration of 25-hydroxycholecalciferol, cobalamin, folic acid, and ferritin were also noted.

It should be emphasized that the magnitude of these changes depends, to a great extent, on the use of various prophylactic substances and procedures (pharmacological preparations, physical exercise) in combination. The transition from hypokinesia to normal activity led to a significant shift in vitamin metabolism in the subjects.

Thus, vitamin metabolism under conditions of 120-day hypokinesia induced changes which were adaptive in nature, testifying to a specific trend in the metabolism of essential nutrients under these conditions and modification of the body's need for vitamins.

OPERATIONAL MEDICINE

(See also: Man-machine Systems M129; Neurophysiology P721)

PAPERS:

P716(16/88) Bogomolov VV.

Problems relating to emergency medical care on manned space flights.

In: Gazenko OG (editor).

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**].

Moscow: Nauka; 1986.

See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.

Pages: 23 - 25.

Operational Medicine, Emergency Care, Reanimation
Humans, Cosmonauts
Space Flight, EVAs

Abstract: As is the case with other types of job performance, nothing about the cosmonaut's job precludes the possibilities of illness, traumatic injury or other conditions requiring emergency medical care. An important aspect of the medical care system in space is medical treatment of sudden acute conditions which may be caused by various types of emergency situations, extreme adverse environmental conditions, aspiration, or, less probable, a somatic disease or metabolic disorder.

The probability that effective medical treatment for the sudden onset of an acute medical problem will be available in space is a function of the reliability of the entire system of medical support of manned flight. In turn, the efficacy of inflight medical support for emergency problems is determined by the adequacy of diagnostic methods and devices, the availability of medical supplies, and the appropriateness of medical strategies.

When acute conditions (e.g., cardiac, circulatory, and respiratory disorders) arise suddenly, effective medical measures must be applied without delay. During his illness, the patient continues to be subject to the effects of space flight factors, possibly including the injurious factor which originally gave rise to the condition. These circumstances make it necessary to have a set of reanimation measures on board to compensate for potentially fatal disruptions of respiration and cardiac activity (respirator, defibrillation equipment, and equipment for closed cardiac massage, and infusion therapy).

Treatment of medical emergencies occurring while cosmonauts are in space suits during EVA is an important issue. Under these conditions, there is a possibility (albeit a small one) of the occurrence of acute medical situations associated with decompression, failure of life support system, vomiting, and traumatic injury. Effective medical aid can be provided through an automated medical care system (automatic hypodermics, electrostimulation devices, and devices to clear the respiratory tract.)

There are some difficulties inherent in the development of medical systems

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to be used to treat disease or medical emergencies under space flight conditions. Emergency return to Earth may be impossible due to technical factors or the condition of the cosmonaut. In addition, the reentry stage, which involves exposure to additional acceleration and inertia and impact stimulation, and also problems in readapting to gravity after relatively long-term adaptation to weightlessness, may have additional negative effects on the patient's condition and complicate subsequent treatment. It is thus clear that medical emergencies must be treated in space, at least until the cosmonaut's condition stabilizes. The desirability of treating illness and injuries during space flight creates the need not only to expand the arsenal of onboard medical supplies and equipment, but also to develop methods and devices for specialized medical care in weightlessness.

Specialized medical care on board spacecraft is facilitated by the presence of a physician. If there is no physician on the crew, it is theoretically possible to transport one to the space station using the shuttle spacecraft. Consultation with medical ground control staff and other qualified specialists can be a great help in determining the medical strategy for inflight treatment. With current levels of technology and expertise, it is theoretically possible to solve the problems described above by creating an "on-board health maintenance facility" which, if necessary, can be used for treatment when in orbit, as well as for returning the patient to Earth.

OPERATIONAL MEDICINE

P717(16/88) Goncharov IB, Polevoy LG, Semeykina LA, Podobuyeva LP.

Determining need for drugs on flights varying in duration.

In: Gazenko OG (editor).

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986].

Moscow: Nauka; 1986.

See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.

Pages: 41 - 42.

Operational Medicine, Drug Supplies, Cardiovascular and Respiratory Systems, Neurophysiology, Motion Sickness, Body Fluids, Immunology, Human Performance

Humans, Cosmonauts

Space Flights, Short- and Long-Term, Soyuz, Salyut

Abstract: Experience with space flight and the results of ground-based experiments have demonstrated that cosmonauts may develop various types of functional disorders in space. The most pronounced problem during the initial days of space flight is vestibular/autonomic disorders and syndromes, caused by fluid shifts resulting from changes in gravity. As a rule, these shifts are short-lived and drugs are used to treat them only in isolated instances. When space flights increase in duration, cosmonauts may develop symptoms of neuroasthenia, cardiovascular deconditioning, changes in fluid-electrolyte homeostasis, decreased immunological sensitivity, and substantial decrease in automicroflora. Because of the possibility of emergency situations, traumatic injuries, or acute medical conditions arising during space flight, it is essential that cosmonauts be provided with drugs for treatment. Specific drugs are chosen by predicting occurrence of functional disorders and diseases and also consideration of flight program and duration, crew size, and presence of a physician on board. In addition, data on susceptibility to disease of people who must work effectively for long periods of time under extreme conditions are utilized.

The special requirements for drugs to be included in the spacecraft medicine cabinet and first-aid kit are somewhat more numerous and rigorous than those in ordinary medical practice. These include high pharmacological activity, potential for multiple uses, and absence of side effects. Because of the limited weight and size of the first-aid and medical kits, the inclusion of such [multipurpose] drugs allows them to be used for the maximum range of indications and also provides for interchangeability and combined use. Special emphasis is placed on the drugs which do not have negative effects on the work capacity of a human operator. Clinical physiological research is performed to verify this property. In order to eliminate the possibility of cases of drug intolerance, each cosmonaut's drug sensitivity is determined during preflight preparation. Determination of drug reliability must include guarantees that they will retain their pharmacological and physicochemical properties under exposure to space flight factors.

The information described above is used to create an inventory of the functional disorders and diseases most likely to arise, the amount of prophylactic and therapeutic measures needed for specific missions and the set of drugs and other therapeutic agents for medical aid.

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For comparatively short space flight on spacecraft of the Soyuz type, cosmonauts are provided with an onboard pharmacological kit for performing first aid. For medical emergencies there are drugs in syrettes for intramuscular injections. On longer space flights, medical treatment may entail therapeutic and/or prophylactic courses of treatment. For this reason, Salyut crews are provided with medical kits containing drugs selected on the basis of functional characteristics and available in greater quantities. During recent years, there have been a number of studies in the area of planning for drug requirements to support space flights varying in duration.

OPERATIONAL MEDICINE

P723(16/88) Romanov AN, Vladimirov IV.

Local hypothermia in treatment of acute diseases of the organs in the abdominal cavity in the practice of space medicine.

In: Gizenko OG (editor).

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986].

Moscow: Nauka; 1986.

See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.

Pages: 116-117.

Operational Medicine, Local Hypothermia; Gastrointestinal System, Diseases of Abdominal Cavity Organs

Humans, Cosmonauts

Space Flight, Hypokinesia with Head-Down Tilt

Abstract: There is nothing to preclude the possibility that acute diseases of the organs of the abdominal cavity requiring emergency surgical intervention will arise during space flight. Because such intervention is currently not possible on board, we have deemed it desirable for the spacecraft's medical arsenal to include effective and simple-to-use methods intended to eliminate or, at least, localize or slow the course of the pathological process. The most promising method from the standpoint of these criteria is regional hypothermia (either external or internal (intra-gastric)), which has been found clinically to be effective in the treatment of such diseases as acute pancreatitis, peritonitis and gastrointestinal hemorrhage.

In order to select a method of regional hypothermia for use in the practice of space medicine, we studied the major changes in homeostasis in response to different methods of cooling the organs of the abdominal cavity under conditions of hypokinesia with head-down tilt. The investigation used 54 men, aged 25-45. Local hypothermia was created using the ALG-2M apparatus on day 8 of hypokinesia with head-down tilt of -8° . A total of 18 subjects were treated with regional hypothermia of the stomach (temperature of liquid circulating in a gastric balloon was maintained at the level of 0°C); 36 were subjected to external abdominal hypothermia (temperature of liquid in a heat exchanger was maintained at -3°C). In the first case, cooling lasted 3 hours and in the second 5 hours.

The results of this research demonstrated moderate change in virtually all parameters studied: central and peripheral hemodynamics, external respiration, acid-base balance, oxygen transport function, and blood rheology, processes of free-radical oxygenation and hemocoagulation. These deviations in functional systems of the body reached their maximal values 1.5-3 hours after beginning the treatment; cooling was functional in nature and did not require special therapy.

External abdominal hypothermia was tolerated better than regional hypothermia of the stomach, did not give rise to unpleasant sensations and autonomic reactions, and had less effect on the parameters studied. In both cases rectal temperature decreased by a mean of 1° .

Thus, because of the good clinical results produced by both methods of regional cooling in the treatment of acute pancreatitis and peritonitis, the

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smaller shifts from homeostasis with external abdominal hypothermia under conditions of hypokinesia with head-down tilt of -8° and ease with which this method can be applied, we recommend the use of the external method of creating abdominal hypothermia in the event that acute pancreatitis or peritonitis arises in space. Because it is so difficult to administer, intragastric hypothermia should be used only when the usual methods do not stop gastrointestinal hemorrhaging.

PERCEPTION: See Human Performance: P708; Neurophysiology P720, P721
PERSONNEL SELECTION: See Neurophysiology P721, Psychology P727

PSYCHOLOGY

(See also: Bionics M121; Endocrinology P733; Group Dynamics P730; Human Performance: all entries; Immunology P706; Metabolism P693, BR 12; Musculoskeletal System P692)

PAPERS:

P726(16/88) Chatterjee RS (India), Kozlovskaya IB, Grigor'yeva LS, Suvorov AS, Singatulin YeG, Vadkhavan JM (India), Dikshit MB (India).

Performance of Yoga on manned space flights.

In: Gazenko OG (editor).

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986].

Moscow: Nauka; 1986.

See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.

Pages: 155-156.

Psychology, Human Performance, Neurophysiology, Musculoskeletal System
Humans, Cosmonauts
Space Flight, Soyuz-T-11, Countermeasures, Yoga Exercises

Abstract: It is well known that regular performance of hatha-yoga exercises facilitates maintenance of good health. Such exercises not only increase physical work capacity, but also make it possible to expand possibilities for voluntary control of various autonomic functions. Yoga exercises are also useful in treatment of various neurotic and psychosomatic disorders. During space flight, crewmembers are subjected to the effects of many physiological and psychological stresses which influence various physiological systems. While many methods are used to counteract the adverse effects of various space flight factors, hatha-yoga was first used on the recent Soviet-Indian flight on the Soyuz-T-11.

This paper presents a detailed discussion of the principles and psychophysical bases for yoga exercises as applied to the goals of space medicine. We consider the effect of weightlessness on circulatory neuromuscular, sensory, and metabolic systems, and describe the techniques for performing yoga exercises, which may eliminate or diminish changes in these systems under space flight conditions.

The goal of the first experiment on the Soviet-Indian flight was to study the effects of functional state on the neuromuscular system. A series of preflight exercises (asana) improved coordination, facilitated relaxation of muscular elastic components in the dynamic phase and significant loading during the static phase of maintaining a position. Performance of the set of yoga exercises preflight produced results comparable in effectiveness to those of the usual set of physical exercises.

During flight, according to data from electronographic records, performance of the set of yoga exercises was first accompanied by decreased bioelectric activity of the extensor muscles (in comparison to baseline); at the same

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time, a decrease in muscle coordination was noted. However, on the subsequent days of the flight, coordination and accuracy with which the exercises were performed increased, and muscular endurance increased substantially. According to EMG data, this improvement was especially marked in the muscles of the back and neck, which were not conditioned in the traditional bicycle ergometer and treadmill exercises. The results support a hypothesis that performance of a set of yoga exercises during space flight had a stimulating effect on the tonic mechanisms for regulating motor activity: it is well known that reflex muscle hypotonia, a regular consequence of weightlessness, substantially decreases the accuracy of the motor control system, which we also observed on day 1 of flight.

Postflight levels of bioelectric activity and coordination first decreased and then recovered rapidly.

The paper also discusses issues pertinent to the performance of yoga in space (limited working space, restraints and recording systems, etc.).

This experiment made it possible to obtain revealing results which justify the inclusion of a set of yoga exercises in the physical training program cosmonauts undergo to prepare for future flights.

P727(16/88) Medvedeva YeYu.

Psychological work capacity as a function of individual differences in emotional traits under conditions of hypokinesia with head-down tilt.

In: Gizenko OG (editor).

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986].

Moscow: Nauka; 1986.

See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.

Pages: 188-189.

Human Performance, Psychological Work Capacity
 Humans, Males, Individual Differences, Personnel Selection
 Psychology, Emotional Traits; Hypokinesia with Head-Down Tilt

Abstract: As manned space missions increase in duration and scope, the role of human factors becomes increasingly important: cosmonauts' tasks as operators and researchers increase in complexity, requirements for reliability and quality of work increase, and new aspects of psychological compatibility become relevant (in particular, when individual crewmembers are replaced). These and other objective principles related to the development of cosmonautics require increasingly detailed and accurate prognosis of psychological work capacity under space flight conditions based on an integrated approach.

Individual differences in emotional traits are important in the hierarchy of factors determining the psychological work capacity of human operators, including cosmonauts. We attempted to identify the relationship between individual emotional factors and psychological work capacity under conditions of simulated weightlessness (hypokinesia with head-down tilt). Research was performed on healthy males aged 26-39. Individual differences in emotional traits were diagnosed in accordance with recommendations developed under the direction of A.Ye. Ol'shannikova, using two questionnaires and a modification of T. Dembo's methodology of self-evaluation. The individual characteristics of the subjects were defined on the basis of whether they showed high or low values for each of a set of 4 emotions: happiness (H), anger (A), fear (F), and sadness (S). As a result the subjects were divided into 8 groups: HAFs, HAFs, Hafs, hAFs, hAFS, HafS, HaFS, and hafs (capital letters indicate high values on the given parameter, lower case low values). Level of psychological work capacity was determined using the following tests: "compensation test," "alphanumeric comparisons," "memory for 20 words," "search for numbers with attention switching," "coding," and "addition of numbers with attention switching."

The subjects belonging to group Hafs showed the highest work capacity during the entire course of a 30-day period of hypokinesia with head-down tilt (-6°). They typically displayed rapid and appropriate response to a new stimulus, absence of difficulty switching attention to other types of activity, and criticalness and initiative in their thinking, all of which characterize the flexible type of adaptation. Groups hAFs, HAFs, hafs, HafS, HaFS showed intermediate levels of work capacity and did not differ much from each other. The group hAFS (with clear domination of negative emotions) showed the lowest work capacity. While they made virtually no errors, this group was extremely slow at task performance. The subjects in

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group Hafs showed high work capacity (as high or higher than HAFs) for the first two weeks), followed by a precipitous drop with recovery coming on day 4 of the recovery period. The data obtained could be used in the practice of space psychophysiology.

RADIOBIOLOGY

(See also: Biospherics P619; Genetics P736; Mathematical Modeling P739;
Metabolism BRL2; Radiobiology P702)

PAPERS:

P688(16/88)* Gaubin Y, Delpoux M, Bionov J, Planel H, Gasset G, Pianezzi B, Burg M, Barbast A. (France).

The effects of space flight factors on biological subjects exposed on the Cosmos-1514 biosatellite.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(6):18-24; 1987.

[7 references; 7 in English]

Radiobiology, Biological Effects, Cosmic Radiation
Botany, Rice, Tobacco; Brine Shrimp; Developmental Biology
Space Flight, Cosmos-1514

Abstract: This paper describes experiments in the Bioblock-5 series, involving brine shrimp cysts, tobacco seeds, and caryopses and sprouts of rice. Two biological collectors were used in this experiment. The first was the traditional biological collector with layers (100 x 800 mm). This container was flown inside the spacecraft behind foil shielding 3 to 5 g/cm³ thick. This container consisted of 8 biological monolayers, 4 compartments where biological subjects were housed in bulk, and thermoluminescent dosimeters. Each monolayer was a metal layer of macrofoil with openings each containing a single subject. One layer contained about 5000 cysts. Two monolayers of *Artemia salina* (brine shrimp) and two layers of tobacco seeds were associated with nuclear emulsion layers. The second biological container was flown outside the spacecraft. Subjects were housed in this container either in monolayers or in bulk in polyethylene bags, in 4 aluminum boxes (40 mm in diameter, 15 mm in height) for which shielding varied in thickness from 0.0015 to 0.3 g/cm². Depending on position of their box in this container, biological subjects received varying degrees of radiation. LiF [Lithium Fluoride] dosimeters were used to determine absorbed dose. It was learned that subjects in the boxes of the outside container with the thickest shielding received the same radiation dose as subjects in the container within the spacecraft. Boxes in the outside container with the thinner shielding received absorbed doses ranging from 0.15 to 0.037 Gy (1 Gy=100 rads). The flight lasted 5 days.

Experiments on *Artemia* utilized eggs (cysts) in the embryonic stage -- gastrules. Such gastrules contain about 4000 cells 200 um in diameter. They are covered with a dense coating and contain only 3% water. Cysts can remain in this stage for many years. After hydration they are again capable of development and reach maturity in 3 weeks. Two types of eggs were used -- one with high and one with low emergence rate. In the flight experiment, cysts were either housed in hermetically-sealed polyethelene bags inside, in non-hermetically sealed containers outside the spacecraft, or in macrofoil layers with openings 250 um in diameter. Artificially hydrated cysts were also used. Postflight, the cysts were kept in a dessicator under controlled conditions. Fifty cysts from each group were placed in a medium with artificial sea salt. After emergence a nutrient medium containing algae was added. The lifespan of 20 individuals from each group was recorded. Only the first 20 days of their lives were studied. This is the period most sensitive

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to environmental factors. Parameters studied included: percent of cysts hatching, percent of emergence, and percent of nauplii (larvae) alive, on day 4 after emergence and up to the point of sexual maturity. The flight lasted 5 days.

Tobacco seeds (Nicotiana tabacum) were chosen for this experiment because they carry a genetic marker which allows identification of the mutagenic effect of environmental factors. Any genetic event affecting one of the alleles will be expressed by a change in chlorophyll synthesis; the affected cell will change color and the generation that follows will have spots (somatic changes) against a dark green background. The number of such changes indicates the number of genetic alterations which have occurred during the plant's development. In this experiment, tobacco seeds were stored in bulk and in monolayers in the internal container and in bulk in the external container. The genetic effect of experimental conditions was assessed by counting the frequency of somatic variations on the two first leaves forming normally from the primordial leaf on the embryo. In addition sprouting speed and rate (percentage sprouting) were observed in the flight and control groups. Morphological anomalies in the cotyledon and new leaves were also recorded.

Experiments were also performed on isolated caryopses and germs of rice plants which were housed in bulk in the internal container and exposed to space for 5 days. Two breeds of rice were used, Tsigalon, with large seeds, and Delta, long-grained with a lower albumen content. Effects were evaluated on the basis of the following parameters: microanalysis of the caryopsis, growth process and length of sprouts after in vitro cultivation. After reentry portions of the caryopses and germs were placed in vials on filter paper in a sterile liquid nutrient medium and cultivated at 25°C. The sprouts were subjected to natural and artificial light with a photoperiodicity of 12 to 24 hours.

Results on Artemia cysts: Internal container. Effects of space flight on dry cysts maintained in the monolayer depended on the type of cyst. Those with a low emergence rate were inhibited in their development, while those with a high emergence rate showed slight facilitation. Dry cysts with low emergence rate flown in bulk showed a slight decrease in the number developing, while cysts with a high inherent emergence rate were not affected. Lifespan was unchanged. Emergence rate of moistened seeds of the high emergence type (others not studied) in bulk was not affected, but a significant degree of stimulation was noted 3 months after first observation. When high emergence rate cysts underwent preliminary radiation (100 and 500 Gy), an inhibitory effect occurred in non-flight hydrated cysts at all stages of development, and in non-flight dry cysts only at the nauplius stage. Exposure of dry cysts to space flight enhanced the effects of radiation. Similar effects occurred on moistened seeds only at radiation dose of 500 Gy. No differences were found in lifespan.

External container. Results were obtained for dry cysts with minimum or maximum shielding. Minimally shielded cysts irradiated in doses from 3 to 16 cGy showed no changes in the stage of nauplius hatching in any condition. Cysts with maximal shielding showed differences as a function of location of

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the biolayer and the way the cysts were housed. Cysts in monolayers showed a significant decrease in percent of emergence at all stages of development. Cysts that were stored in bulk only showed decreased emergence rate when irradiated in a dose of 0.12 Gy.

The authors conclude that the effects of space flight factors on *Artemia* cysts depend on the physiological state of the subjects and the way they are housed in space. Only cysts with a low emergence rate flown within the spacecraft showed inhibited development after flight. *Artemia* cysts have a very low hydration percentage. The amount of water they contain can be increased artificially, but only in cysts in bulk in a hermetically isolated medium rather than in a monolayer. Hydration affected only cysts irradiated with gamma-rays preflight. Preliminary irradiation made it easier to identify the effects of space flight factors, since decrease in larvae viability was greater in the flight group. Results of this experiment appear paradoxical with respect to effects on cysts flown outside the spacecraft, since developmental inhibition occurred only in cysts which had maximal radiation protection.

Results on tobacco seeds. (*Nicotiana tabacum*). Frequency of somatic reactions increased significantly (by a factor of 2) in the cotyledon and first 2 leaves of the seeds of flight groups compared to those of control groups. No effects of mode or place of storage were found, nor were effects on speed or percent of sprouting. Genetic effects of space flight found in this experiment contrast with those of the previous "Bioblock-2" and "Bioblock-3" experiments.

Results on isolated caryopses and germs of rice plants (*Oryza sativa*) No significant differences were found in the developmental progress of flight and control seeds, nor were there any differences in mineral components.

Table 1: Percent of emergence of dry cysts, stored in monolayers or in bulk, with varying inherent emergence rate

Condition	Cysts with high rate		Cysts with low rate	
	Monolayer	Bulk	Monolayer	Bulk
Control	77.0	86.80	60.80	70.40
Flight	81.40	83.80	49.00*	60.60*

Here and in Tables 2 - 4: * - differences between conditions statistically significant.

Table 2: Percent of emergence of cysts with different levels of hydration in experiments I and II

Condition	Experiment I		Experiment II (3 months later)	
	Hydration, %			
	3	68	3	68
Control	86.80	62.40	80.20	75.30
Flight	83.80	67.60	88.00*	81.60*

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Table 3: Rate (in %) of hatching (1), emergence (2), and nauplius development (3) in irradiated and non-irradiated, dry and hydrated Artemia cysts (internal container)

Rad. Dose, Gy	Condition	Hydrated cysts			Dry cysts		
		1	2	3	1	2	3
0	Control	76.2	75.3	69.6	82.6	80.2	75.8
	Flight	85.5*	81.6*	72.6	88.8*	88.0*	82.2*
100	Control	67.5	66.8	61.2	85.4	84.6	75.6
	Flight	65.7	63.5	56.4*	82.0	82.0	70.0*
500	Control	61.7	60.5	55.2	82.4	80.0	50.6
	Flight	57.2*	56.7	49.7*	79.4	76.4	43.0*

Table 4: Percent of cysts hatching as a function of whether they were stored in a monolayer or in bulk on the outside of the biosatellite

Cysts	Condition	Monolayer			Bulk	
		Dose, cGy			0.12	15
High developmental success rate	Control	0.12	3	15	80.70	81.0
	Flight	73.40*	69.00	79.80	75.20*	82.2
Low developmental success rate	Control	50.20	55.20	45.40	62.2	61.6
	Flight	40.60*	50.60	42.80	65.5	58.0

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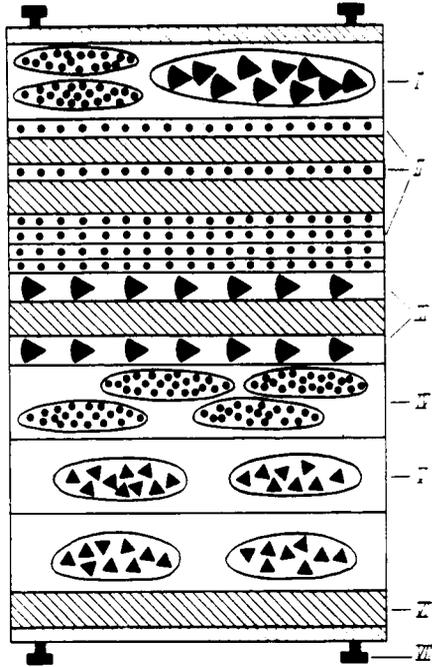


Figure 1

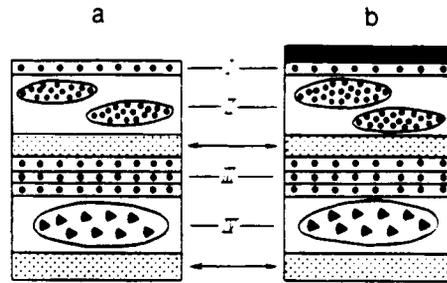


Figure 2

Figure 1: Diagram of the inside biocollector container
 I - Artemia cysts and tobacco seeds, in bulk; II - Artemia cysts in monolayers; III - tobacco cysts in monolayers; IV, V - Artemia cysts and rice in bulk; VI - nuclear emulsions; VII - metal rods

Figure 2: Diagram of the outside biocollector with different shielding
 a - shielding of 0.0015 g/cm^2 ; b - shielding of 0.35 g/cm^2 . I, II - Artemia cysts in monolayer and in bulk, respectively; III - Artemia cysts in monolayer; IV - tobacco in bulk. Arrows indicate dosimeter.

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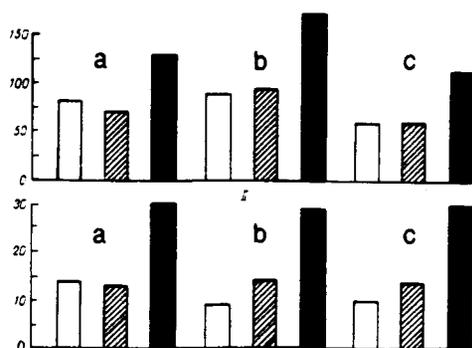


Figure 3: Genetic effect and morphological anomalies in cotyledons of tobacco shoots.

I - number of changes per 100 cotyledons; II - number of anomalous plants (in %). White bars - laboratory control; hatched bars - transport control; solid bars - flight. a, b - inside and outside collectors, bulk storage; c - monolayer in grid.

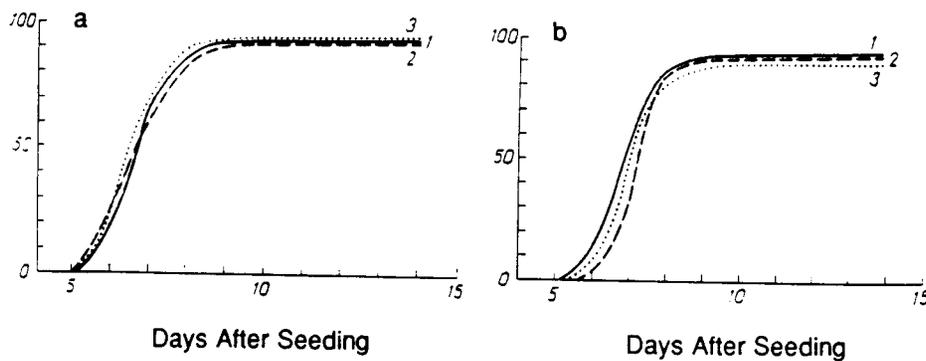


Figure 4. Sprouting of tobacco seeds stored in bulk (a) and in a monolayer (b)

Abscissa - time after seeding (in days); ordinate - number of sprouting seeds at the two-cotyledon stage (in %) 1 - flight; 2 - laboratory control; 3 - transport control.

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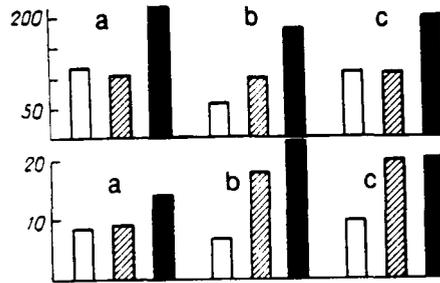


Figure 5: Genetic effect and morphological anomalies on the first two leaves of tobacco plants

1 - number of changes per 100 leaves. Other symbols as in Figure 3.

P710(16/88) Fedorova NL, Shafirkin AV, Osipova YeYu.

Quantitative description of radiation damage to the spermatogenic epithelium and rate of recovery after exposure to fast neutrons and gamma-irradiation.

Radiobiologiya.

XXVII(4): 492-496; 1987.

[8 references; 3 in English]

Authors' affiliation: Institute of Biomedical Problems, USSR Ministry of Health, Moscow.

Reproductive Biology, Spermatogenic Epithelium

Mice, Male

Radiobiology, Radiation Damage, Fast Neutrons, Gamma Radiation

Abstract: In this experiment male mice, aged 1.5 months, were exposed to a single dose (60 or 150 Gy) of irradiation with fast neutrons of the reactor spectrum with dose rate of 0.78 cGy/min, and two doses (150+150 cGy) with an interval of 120 days. The contribution of gamma radiation was 40% of the neutron dose. A total of 700 mice were used. For purposes of comparison, a separate group of mice was exposed to ^{137}Cs in doses of 200, 400, and 600 cGy with a dose rate of 30 cGy/min. Effects on spermatogenesis were assessed on the basis of changes in the number of cells showing different degrees of differentiation in a 1 ml suspension of testis during the postirradiation period. Total number of types A, B, and intermediate spermatogones were counted. Animals were examined every 4-7 days during the first 2 months after irradiation and every 2 weeks subsequently. At each point in time 10 mice were studied. Radiation damage to the spermatogenic epithelium was defined as logarithm of the ratio of a given type of cell in the experimental group to that of the control groups.

Results of varying doses of neutron and gamma-irradiation on relative numbers of spermatocytes, spermatids, and spermatozoids over time are presented in Figure 1. Data show that spermatogenic cells are highly sensitive to radiation. The number of spermatocytes decreased with dose in exponential fashion with D_0 equal to 35 and 120 cGy for neutron and gamma-radiation, respectively. The mature portions of spermatogenic cells (spermatids and spermatozoids) were more affected by radiation with D_0 equal to 20 and 55 cGy for the two types of irradiation. Rate of recovery was negatively associated with dose, as described by the equation

$$T = T_1^{(0)} e^{0.00099D},$$

with $T_1^{(0)}$ — standing for the half-recovery period.

Table: Duration of period for half-recovery from radiation damage in the spermatogenic epithelium as a function of absorbed doses of neutron and gamma-radiation

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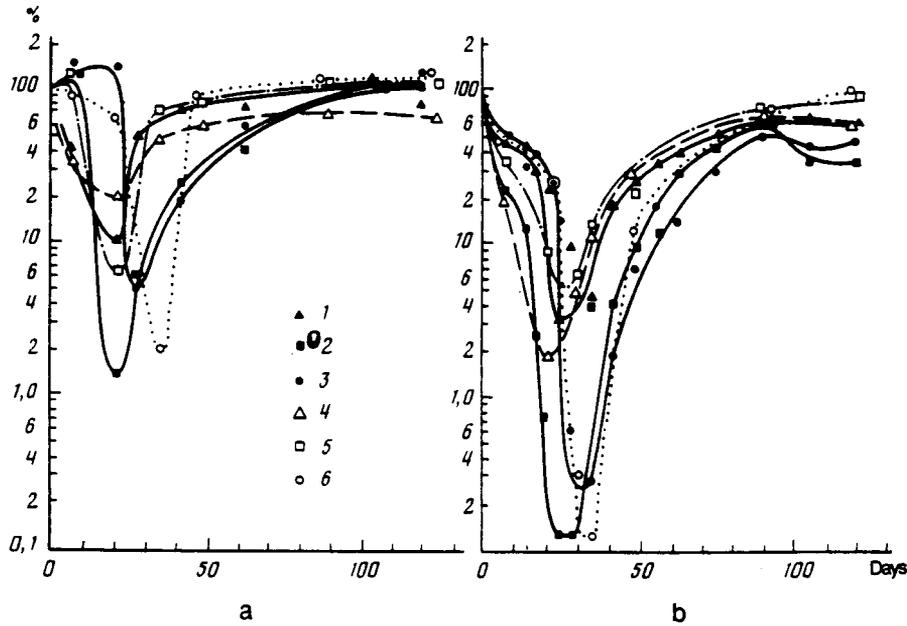


Figure 1: Relative change in number of cells of the spermatogenic epithelium after exposure to fast neutrons in a dose of cGy (a) and 150 cGy (b) and gamma-radiation in doses of 200 cGy (b)

Abscissa - time after irradiation, days; ordinate - relative quantity of cells, %. 1 - 3 - quantity of spermatocytes, spermatids, and spermatozoids, respectively, after exposure to neutrons, 4 - 6 - quantity of spermatocytes, spermatids, and spermatozoids, respectively, after gamma-irradiation.

Figure 2: Minimum relative quantity of cells in the spermatogenic epithelium as a function of absorbed dose of fast neutrons and gamma-radiation.

Figure 3: Half-recovery periods from radiation damage in the spermatogenic epithelium as a function of equivalent dose for the fast and slow recovery components

P711(16/88) Ul'yanova VA, Shafirkin AV, Farber YuV, Markelov BA.
Characteristics of development of radiation damage and recovery processes in the hemopoietic tissue of mice after repeated exposure to fast neutrons and gamma-irradiation.

Radiobiologia.

XXVII(4): 510-515; 1987.

[9 references; 2 in English]

Authors' affiliation: Institute of Biomedical Problems, USSR Ministry of Health, Moscow

Hematology, Hemopoietic Tissue

Mice

Radiobiology, Fast Neutrons, Gamma Irradiation, Repeated Exposure

Abstract: More than 1500 mice were used in this experiment. The animals were exposed to 1, 2, 3, or 4 doses of fast neutrons at a dose rate of 8-38 cGy/min. Total dose was 150, 300, 450, and 600 Gy, respectively for the different numbers of exposures. The contribution of gamma irradiation was 10% for the study of hemopoietic stem cells, and 30% for the study of other hemopoietic parameters. In a separate series of trials, including only gamma irradiation, the dose for this fraction was found to be approximately equal to a total dose of 210 cGy. Interval between radiation doses was 2 months. Effects of this treatment on the hemopoietic system was assessed on the basis of number of hemopoietic stem cells (measured by the exocolony method), number of karyocytes in marrow of the femur bone and muscles, and mature functional cells in blood at various intervals after each irradiation session.

Results showed that the relative number of hemopoietic stem cells decreased by an order of magnitude of nearly two after each exposure to neutrons at a dose of 150 cGy. The minimum number of hemopoietic stem cells was 1% after the first exposure, and 2.5-4% after subsequent doses. Recovery of stem cells after a single neutron dose began on day 6, approximately the same latency as occurs after gamma irradiation in the same dose. During the initial more rapid phase of recovery, number of cells doubled in about 24 hours; subsequently, rate of recovery slowed. After repeated exposure to radiation, the recovery process began somewhat earlier, but was slower. Minimum percentage of myelokaryocytes after the first, second, and third irradiation doses was 5.7%, 9.0% and 8.0% of the norm. A smaller decrease in the total number of bone marrow cells is evidently associated with compensatory increase in proliferation of bone marrow cells. The decrease in number of reticulocytes in peripheral blood (6.7%-9% of the norm) was similar to the decrease in karyocytes. Recovery of these parameters was very rapid, and the number of cells equalled that of control animals 10-15 days after irradiation. Increase in erythropoiesis was noted, with the number of reticulocytes several times normal levels. After the third irradiation session, recovery of karyocytes and increase in reticulocytes was less pronounced. After the first two irradiations by neutrons, the concentration of erythrocytes and level of hemoglobin in the blood decreased by approximately 30%. After the third irradiation, decreases reached 40-50%. The rate of recovery of erythrocytes was slower after each successive irradiation. Leukocytes and lymphocytes behaved similarly. Irradiation by neutrons decreased neutrophils to 20-10% and lymphocytes to 7-3% of the norm; rate of recovery slowed by a factor of 2.5-3.5 after the last two irradiations. Effects of matched levels of gamma irradiation were much less

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severe. However, recovery rates were analogous for the two types of radiation, if equally effective doses were compared. (Half) Recovery period was a direct function of radiation dose as described by the equation

Table 1: Relative change in parameters of the hemopoietic system in mice

Table 2: Half recovery periods (days) for the hemopoietic system as a function of absorbed dose for neutron and gamma-irradiation

Figure 1: Development of radiation damage and recovery in the hemopoietic system in mice exposed to repeated doses of fast neutrons and gamma-radiation

Figure 2: Half recovery period for the hemopoietic system as a function of equivalent dose of radiation

P712(16/88) Antipov VV, Fedorov VP, Ushakov IB, Davydov BI.

Changes in synapses after irradiation of the heads of rats.

Radiobiologiya.

XXVII(5): 644-649; 1987.

[14 references; none in English]

Authors' affiliation: Institute of Biomedical Problems, USSR Ministry of Health, Moscow

Neurophysiology, Synapses

Rats

Irradiation, Gamma-Irradiation, Head

Abstract: The heads of 200 male Wistar rats were irradiated with gamma-quanta ^{60}Co in doses of 2, 6, 10, 50, 100, 200, 400, and 100 Gy at dose rate of 6 cGy/sec. In a unilateral irradiation condition, the rats were placed in special stalls which prevented them from moving with respect to the radiation sources and allowed 75% of the body to be screened. The rats were sacrificed 0.1, 0.8, 1.7, and 5 hours after exposure. Brain tissue was removed and fixed. Tissue from the sensorimotor cortex, hippocampus, caudal nucleus, thalamus, and cerebellar vermix cortex were studied. Ultrafine sections were obtained, stained, and studied under an electron microscope. Interneuronal contacts and myeloarchitectonics were also studied in stained sections.

Irradiation of the head of rats in doses of 2-10 Gy led to no changes in synapse architectonics in any region of the brain, although some swelling of presynaptic neurons did occur.

When doses of 50-100 Gy (lethal) were used, changes in synapse architectonics were very clear and developed in discrete phases. Immediately after irradiation, there was moderate swelling of the presynaptic region and decrease in the number of vesicles. Synaptic membranes retained their integrity and normal osmiophilic characteristics. It was not possible to determine whether any region of the brain was affected more than others. After 0.8 hours there were significant changes in the majority of interneuronal contacts. Concentration of synaptic vesicles had virtually normalized suggesting compensatory processes and related by the authors to protein synthesis. However, there were also a significant number of interneuronal contacts showing destructive changes, particularly of the light or focal type. After 1.7 and particularly 5 hours, synapses with damaged pre- and postsynaptic membranes began to be seen. Although, the majority of synaptic contacts had the normal organization of vesicles, mitochondria, and membranes, in some areas vesicles were diminished in number or completely absent and vesicle contours were disrupted. The most labile synapses were those in the spines of the dendrites. Most extreme changes were noted in the sensorimotor cortex and caudal nucleus.

When radiation dose was 200 Gy, a typical cerebral syndrome developed. In the initial postradiation period, symptoms of neurological damage (e.g, tremor, ataxia, hyperkinesia) were noted. Immediately after radiation massive impoverishment of preterminal synaptic vesicles was noted. In addition, there were instances where the presynaptic regions were overfilled with vesicles which adhered to the center of the terminal or the presynaptic membrane. Synapses with focal destructive changes in the

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membrane were very common. After 0.8 and especially 1.7 hours, these changes were more pronounced, affecting virtually every interneural contact. The most common type of change remained "light" degeneration. After 5 hours most synapses showed various irregularities and destruction of the vesicles and there was mass destruction of the spines of the dendrites. The postsynaptic membrane was uneven in thickness and osmophilia, and had partially disintegrated. With this dose of radiation changes were noted in all areas of the brain and in all types of interneural contacts; however, the greatest polymorphism was noted in the sensorimotor cortex and hippocampus.

Irradiation of the head at a dose of 400 Gy caused immediate neurological damage. Electron microscopy clarified the leading role played by changes in interneural contacts in the development of neurological symptoms. The most pronounced changes occurred in the specialized components of the nerve cells, neurofilaments, spines of the dendrites. The synaptic space was frequently either enlarged or filled with osmophilic material. Synaptic degeneration of the dark type occurred in various areas of the brain; however, light degeneration remained the most common. The authors call attention to the polymorphism of changes in synaptic architectonics at this radiation dose. Irradiation at 1000 Gy caused death in the animals being treated and destruction of the nerve cell membrane structure. Such changes affect the protein synthesizing, metabolic, and particularly specialized subsystems. One may speak of asynapsia at this dosage. The most typical degeneration remains light and focal. Destruction is so ubiquitous that it is not possible to identify regions of the brain most affected

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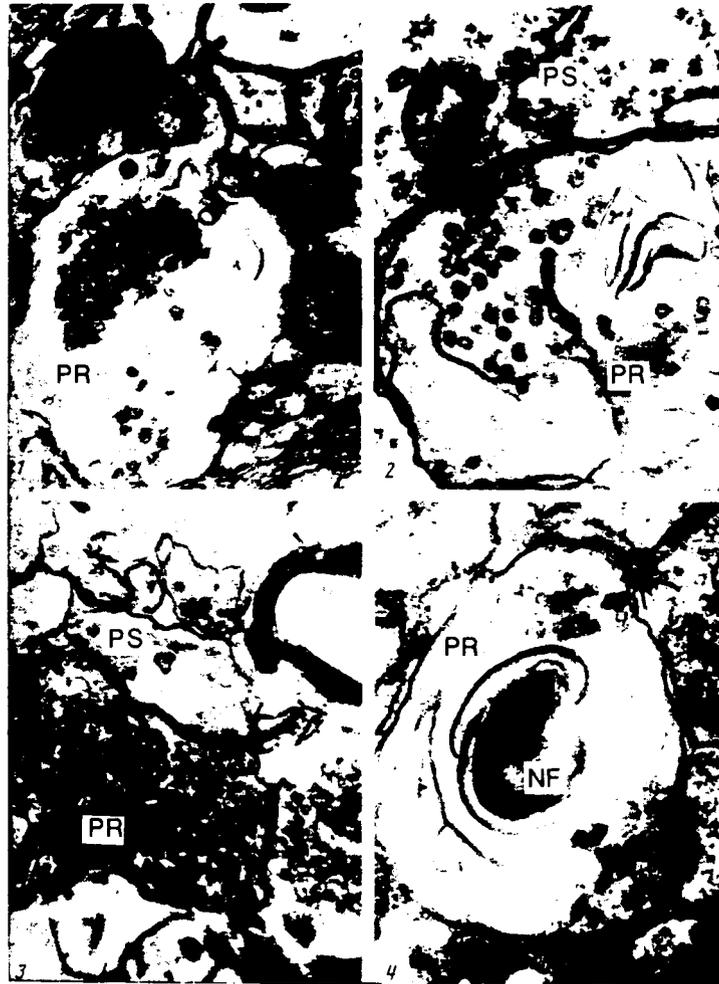


Figure: Synapse degeneration. 1 - light degeneration in the sensorimotor cortex 0.8 hours after irradiation of the head (50 Gy); 2 - in a Purkinje cell 5 hours after irradiation of the head (200 Gy); 3 - dark degeneration in the sensorimotor cortex 0.8 hours after irradiation of the head (400 Gy); 4 - filamentary degeneration in the thalamus 1.7 hours after irradiation of the head (400 Gy). Mag. 80,000. PR - presynaptic area; PS - postsynaptic area; NF - neurofilaments.

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P713(16/88) Gerasimenko VN, Portman AI, Bulanova M, Ivanov B, Mileva M.
The effect of charged particles of relativistic energy on the frequency of chromosome aberrations in human blood lymphocytes. Dose — response and RBE of protons, deuterons and helium ions.

Radiobiologiya.

XXVII(6): 743-747; 1987.

[16 references; 1 in English]

Authors' affiliation: Institute of Biomedical Problems, USSR Ministry of Health, Moscow.

Genetics, Chromosome Aberrations; Hematology, Lymphocytes

Humans

Radiobiology, Gamma Radiation, Protons, Deuterons, Helium Ions; Dose-Effect, RBE

Abstract: This experiment investigated the frequency of chromosome aberrations in lymphocytes of peripheral human blood after exposure to protons, deuterons, and helium ions. Lymphocytes in the G_0 stage were irradiated in glass flagons on a synchrotron with protons of 9 GeV, deuterons, and helium ions of 4 GeV/nucleon in doses of 0.20-4.0 Gy, dose rate of 0.05, 0.006, and 0.008 Gy/sec. respectively. LET for protons was 2.28, for deuterons was 2.14, and for helium ions was $8.0 \text{ MeV}\cdot\text{g}^{-1}\cdot\text{cm}^2$. Cells were also irradiated with ^{60}Co gamma-quanta with a dose rate of 0.11 Gy/sec., and LET of $2.50 \text{ MeV}\cdot\text{g}^{-1}\cdot\text{cm}^2$. After the material was cultured for 54 hours, all aberrations observable without karyotyping were counted.

Number of cells showing aberrations varied linearly with dose of standard radiation. For charged particles, number of aberrant chromosomes was a linear function of dose only to a certain point (approximately 2.5 Gy). The authors attribute this to retarded division of cells containing multiple chromosome damage induced by exposure to high doses of high energy particles. Irradiation with charged particles led to more extreme effects than gamma irradiation; virtually 100% of cells exposed to helium ions at 4.0 Gy showed aberrations; the corresponding percentage was 80% for protons. When mean number of aberrations per cell was plotted as a function of dose of different types of radiation, it was obvious that the biological effectiveness of charged particles was much higher than that of gamma rays. For doses of 1.0-4.0 Gy, protons, deuterons, and helium ions induced twice as many chromosome aberrations as gamma rays. Helium ions were most effective. As radiation dose increased the number of aberrations per cell attributable to a unit dose (1 Gy) also increased. Distribution of aberrations among cells deviated significantly from a Poisson distribution for the charged particles, suggesting inhomogeneous distribution of absorbed energy. Examination of types of aberrations induced by the different types of radiation revealed that the particles were characteristically associated with exchange type aberrations (dicentric and ring aberrations). Computed biological effectiveness of the different type of particles is presented in Table 2. The authors attribute the high biological effectiveness of these particles to the enhanced probability of formation of nuclear reactions under exposure to high energy radiation, accompanied by the formation of secondary radiation with high LET.

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Table 1: Structural aberrations in human blood lymphocytes after irradiation with charged particles of relativistic energy and gamma rays

Type of radiation	Dose, Gy	Number of cells counted	Types of aberration (per 100 cells)			
			Chromatid fragments	Paired acentric fragments	Point fragments	Dicentric and rings
⁶⁰ Co -Rays	0	600	0.7	2.5	0	0.4
	0.25	200	1.5	3.5	1.0	0
	0.50	200	2.5	6.8	0	3.5
	1.00	200	4.0	10.0	4.0	10.0
	2.00	200	4.0	18.0	15.0	27.5
	4.00	200	6.0	52.0	26.0	82.0
Helium ions, 4 GeV/nuclon	0	200	1.5	1.5	0	0
	0.50	300	2.0	8.5	3.0	3.3
	1.00	300	5.0	18.0	11.7	15.7
	2.50	200	13.0	48.5	27.0	81.0
	3.00	200	13.0	71.0	52.5	97.5
	4.00	200	22.5	90.5	87.0	223.0
Protons, 9 GeV	0	200	0.5	2.5	0	0.5
	0.20	200	2.0	5.0	5.0	3.5
	0.55	200	2.5	7.5	2.0	5.5
	1.00	200	2.0	13.0	15.5	21.0
	2.00	200	5.0	38.0	35.0	45.0
	4.00	200	14.0	103.0	78.0	141.0
Deuterons, 4 GeV/nuclon	0	800	1.3	3.3	0	0
	0.26	800	1.1	6.1	0.3	0.5
	0.49	800	0.7	11.6	0.8	7.7
	0.97	800	2.8	19.1	3.5	23.3
	2.02	800	3.5	39.0	8.0	55.7
	3.81	800	6.0	108.4	21.4	148.7

Table 2: RBE coefficients of accelerated charged particles with relativistic energy

Biological Test	Type and energy of radiation		
	Helium ions 4 GeV/nuclon	Protons 9 GeV	Deuterons 4 GeV/nuclon
Number of aberrant cells	1.8	1.4	1.8
Total number of aberrations	1.7	1.6	1.6
Number of paired acentric fragments	1.4	1.3	1.6
Number of dicentrics and rings	1.9	1.4	1.9
Mean RBE value	1.7	1.4	1.7

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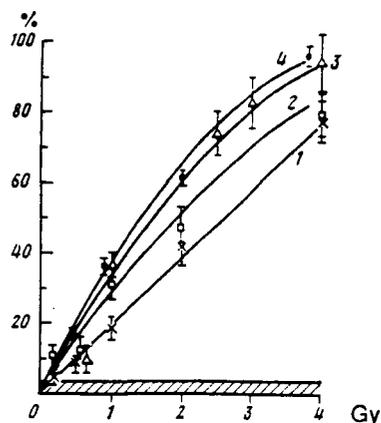


Figure 1: Frequency of aberrant cells in a culture of lymphocytes of human blood as a function of dose of gamma rays (1), protons (2), helium ions (3), deuterons (4)

Abscissa - radiation dose; ordinate - percent of cells with chromosome aberrations. Hatched area - control.

Figure 2: Change in total number of chromosome aberrations in a culture of human lymphocytes as a function of dose of gamma rays, protons, helium ions, and deuterons

Figure 3: Change in the number of dicentric and rings in a culture of human lymphocytes as a function of dose of gamma rays, protons, helium ions, and deuterons

RADIOBIOLOGY

P738(16/88) Kovalev YeYe, Sakovich VA.

The concept of radiation risk in setting radiation safety standards for space flights.

In: Gazenko OG (editor).

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986].

Moscow: Nauka; 1986.

See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.

Pages: 314-315.

Radiobiology, Radiation Safety, Radiation Risk
Humans, Theoretical Article
Space Flight, Standard Setting

Abstract: In developing a set of "radiation safety standards for the crew of spacecraft during space flights" we made most use of the standard "safety standards for flights up to three years in duration." This standard uses a more logical definition of the concept of radiation risk than "Temporary standards of radiation safety for space flights" (VNRB-75), which is currently in force. In "Terms and definitions" of the same set of standards (GOST 26545.201-83) the radiation risk to the spacecraft crew is defined as the risk associated with radiation effects on the crew during space flight. "Method of computing radiation risk" (RD 50.25645.205-83) establishes that this risk can be defined quantitatively by integrating -- over the whole duration of the flight and all possible values of the total dose -- the product of the probability density of each value of the total dose at a given moment of time and the value of the total radiobiological effect corresponding to the value of the total dose.

The normative level of radiation risk as a function of flight duration T (in months) was established on the basis of analysis of statistical data on the frequency of lethal outcomes as a function of age, type of occupation, and cause of death. It is typically given in the form

$$\Delta R = 0.06 \cdot 10^{-4}.$$

This increases the occupational risk of a civil aircraft crew somewhat and corresponds to relatively safe occupational conditions. Such criteria of radiation safety, as distinguished from the normative value of radiation and probability of exceeding it established in VNRB-75, allows a more adequate estimate of the probability that characteristics of radiation conditions will lead to the occurrence of radiobiological effects. Other normative quantities were established at levels accepted in VNRB-75. This is also true of the maximum acceptable dose during job performance and the dose of a single exposure during a space flight, which equals 4.0 and 5.0 Zv, respectively. In the absence of probability conditions of radiation effects, the normative levels of radiation risk for one- and two-year flights correspond to doses of about 0.70 and 1.2 Zv.

REPRODUCTIVE BIOLOGY

(See also: Developmental Biology P689; Endocrinology P733; Radiobiology P710)

PAPER:

P724(16/88) Tikhomirov YeP, Prilepskaya VN, Aleksashkina NI, Samokhin VG.
Tolerance of lower body decompression in women.

In: Gazenko OG (editor).

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**].

Moscow: Nauka; 1986.

See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.

Pages: 136-137.

Reproductive Biology, Reproductive Organs and Functions; Cardiovascular and Respiratory Systems, Functional State
Humans, Women
LBNP, Tolerance

Abstract: Decompression of the lower body may be used in space flight for several purposes: as a provocative test for evaluating the state of the cardiovascular system, as a method of preventing orthostatic intolerance, and as a technique for preventing discomfort during the acute period of adaptation to weightlessness. The widespread use of this method, and the participation of women in space flight makes it essential to study tolerance of lower body decompression in females.

Four healthy women, aged 25-32, participated in this study. Lower body decompression was created while they were in horizontal position wearing the "Chibis" vacuum suit according to the provocative test decompression schedule actually used on Salyut space stations: 25 mm Hg - 2 minutes, 35 mm Hg - 3 minutes, 40 mm Hg - 5 minutes, 50 mm Hg - 5 minutes. Each subject participated in 3 sessions at intervals of 2-3 days. A control group consisted of 8 women.

Responses of the cardiovascular and reproductive systems, external respiration and gas exchange were recorded. The reproductive system was studied longitudinally: for one menstrual cycle before the experiment began, in the cycle during which the experiment occurred, and for 1-2 subsequent cycles. Functional status was evaluated using methods for analyzing anamnestic data, a gynecological examination, and functional diagnostic tests (rectal temperature, pupil test, vaginal smears for computation of the karyopyknotic index, study of the gonadotropic function of the pituitary and gestagenic functions of the ovaries based on results of radioimmune assay of the plasma concentration of prolactin and progesterone, study of production of androgens by the kidneys using data on renal excretion of 17-corticosteroids).

All the women showed good tolerance of decompression. No discomfort was noted. Toward the end of the test, i.e., during minute 5 of negative pressure of 50 mm Hg, the following measurements were recorded (mean of 12 sessions): 10% decrease of blood perfusion in the chest cavity, 3% increase of leg volume, 27% increase in heart rate, 60% decrease in

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cardiac stroke volume, 45% decrease in cardiac ejection, 9% increase in minute respiratory volume, 26% increase in breathing volume, 18% decrease in oxygen consumption. Pulsed pressure in the brachial artery tended not to drop below 30 mm Hg and only reached 20 mm Hg in two instances. Decompression did not induce clinically observable anatomical changes in the sex organs, did not alter the nature and duration of the menstrual cycle, did not alter or activate the hormonal function of the ovaries, nor did it affect the gonadotropic function of the pituitary or the androgenous function of the renal cortex.

Based on analysis of the functional status of the cardiovascular and respiratory systems during the test, the results of a gynecological examination directly after it, subjects' reports, and also the study of the reproductive system over a period of one year, the investigators conclude that the women showed good tolerance of the lower body decompression procedure using the "Chibis" suit in a provocative test regimen.

Montgomery et al. (1977) noted women's poor tolerance of lower body decompression at 60 mm Hg compared to that of men. This difference, if real, may have resulted from anatomical differences in women's bodies which affect the ratios among volumes of the portions of the body undergoing decompression (V_H) to those of the rest of the body (V_B). All else being equal, this ratio has a decisive influence on tolerance of lower body decompression. In Montgomery's data this ratio is considerably different for men and women. Measurements for our data gave the result: $V_H/V_B = 1.30$.

SPACE BIOLOGY

PAPERS:

P729(16/88) Grigoryan EN, Mitashov VI, Tuchkova SYa, Cherdantseva YeM.

Regeneration in tritons in space.

In: Gazenko OG (editor).

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986].

Moscow: Nauka; 1986.

See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.

Pages: 268-269.

Space Biology, Regeneration

Amphibians, Tritons

Space Flight, Weightlessness, Theoretical Article

Abstract: The effect of weightlessness on the processes of regeneration has not yet been studied. Among the lower vertebrates the greatest regenerative capacity belongs to tissues of caudate amphibians. Legs and eyes of adult tritons (salamanders) are the classical experimental model for studying the regeneration process. The regeneration potential of these tissues can be measured on the basis of a number of experimental-embryological, autoradiographic, and electron microscopic studies. It is known that such external factors as temperature, level of radiation, and mechanical stress to which the regenerating tissue is exposed influence the regeneration process.

In connection with the issue of the role of gravity in the regeneration process, it is of particular interest to juxtapose two experimental models - regeneration of the crystalline lens from the dorsal portion of the iris and regeneration of the distal portion of the leg in tritons. Regeneration of the skeletal muscle system of legs is determined, to a significant extent, by the structure of mechanical stress arising within the regenerating blastema, which in turn depends on the nature of the mechanical loading to which the leg is subject as it fulfills its support function. One hypothesis (Nace, 1983) asserts that a certain portion of the energy of basal metabolism must be expended on supporting "positional homeostasis" of the regenerating blastema in the gravitational field. Weightlessness, thus, can lead not only to change in the structure of mechanical stress on the regenerating tissue, but also to change in the level of basal metabolism and, in consequence, to change in the level of proliferative activity of the blastema cells, which may be identified through autoradiographic studies. On the other hand, the process of regeneration of the lens would depend significantly less on the functional mechanical loadings.

Thus, comparison of the regeneration of the musculoskeletal system of legs and regeneration of the crystalline lens in weightlessness, allows us to evaluate the role of gravity in these processes, and also to identify the regulatory mechanisms of regeneration, which are capable, to varying degree, of compensating for alterations in gravity.

SPACE BIOLOGY

P732(16/88)* Il'in Ye A, Anitpov VV.

Future prospects for the development of space biology.

In: Gazenko OG (editor).

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina: Tezisy dokladov VIII Vsesoyuznoy Konferentsii, Kaluga, 25-27 June 1986 [**Space Biology and Aerospace Medicine: Abstracts of papers delivered at the Eighth All-Union Conference, Kaluga, 25-27 June 1986**].

Moscow: Nauka; 1986.

See: Abstract M117 (Space Biology and Medicine) Digest Issue 14.

Pages: 273-274

Space Biology, Ecological Physiology; Life Support Systems, CELSS;

Exobiology,

Theoretical Article

Future Prospects, Biosatellites, Mir

Abstract: [Paragraphs reviewing past accomplishments omitted.] On the basis of past results, we can conclude that the major research trends in the area of space biology will not change radically over the next 10-15 years. In the area of ecological physiology, these will include gravitational physiology, biological rhythms, radiobiology, and study of combined effects of space flight factors. Areas of magnetic biology, photobiology, and population genetics will undergo further development. The problem of the creation of closed ecological systems will be addressed more intensively, than it has been previously. A major focus will be the creation of space greenhouses, which will fulfill the function of partial regeneration of space station atmospheres, and the plants which will be used to supplement crewmembers' diet.

Goals in the area of exobiology, as now, will involve determining conditions essential for life to arise, and use of direct or indirect methods to study the possibility of the existence of various forms of life, beginning with simple organic molecules, in space, on other planets, (particularly those in the solar system, and on planetary satellites.

Work toward the goals of space biology will be undertaken on flights of unmanned spacecraft, on board manned space station complexes, and in ground laboratory conditions. As has been the case in previous years, investigations on biosatellites will play an important role. The next biosatellite be launched in 1987. The 14-day flight will include experiments to study the principles of structural and functional restructuring in the bodies of animals during the initial (days 1-7) and transitional (days 8-14) periods of adaptation to weightlessness. These studies will use two primate (rhesus-macaques) and 10 rats. Also planned are studies of the influence of weightlessness on the reparative regeneration of tissues (amphibians), development and behavior of fish, state of unicellular organisms and permeability of their membranes (paramecia), and growth and development of plants. Subsequent biological experiments on biosatellites will be conducted on a 2 year basis.

Effective solution of the problems in space biology may be facilitated by the creation of a specialized biomedical laboratory equipped with the latest scientific research apparatus and on-board computer technology in the base module of the Mir space station. It would be desirable to incorporate functional compartments and zones in the design of the

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specialized biomedical laboratory. The most important of these would be compartments for performing physiological research on humans and animals, a surgical area, and a compartment for housing biological subjects. Such a design would ensure the necessary conditions for effective completion of the research program.

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READERS

Translations and abstracts of recent Soviet publications, including those of interest to specialists in space life sciences, are published by Joint Publications Research Service (JPRS). There are three series of JPRS reports relevant to space life science: Series USB, Science & Technology, USSR: Space Biology and Aerospace Medicine includes a cover to cover translation of the Soviet journal Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina (8 issues per year); Series ULS, Science & Technology, USSR: Life Sciences, containing mainly short abstracts with some complete translations (20 issues per year); and Series USP, Science & Technology, USSR: Space, containing translations of newspaper reports, short abstracts, and translations (6 issues per year). Individual JPRS publications may be ordered from the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22161. The phone number of NTIS is (703) 487-4600 and telephone orders are encouraged. Prices depend on number of pages; a recent issue of Space Biology and Aerospace Medicine, for example, cost \$16.00. When ordering, it is recommended that the JPRS number, title, date and author, if applicable, of publication be cited. An order takes 9-30 days to arrive. Rush orders are possible, but involve an additional charge. There is a significant and variable lag period between the time a JPRS publication is completed and the time it is orderable from NTIS.

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JPRS REPORT
SCIENCE AND TECHNOLOGY
JPRS-USB-88-003 25 FEBRUARY 1988

USSR: SPACE BIOLOGY AND AEROSPACE MEDICINE
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Abstracted in Digest Issue 15.

JPRS REPORT
SCIENCE AND TECHNOLOGY
USSR: LIFE SCIENCES

JPRS-ULS-87-013 5 November 1987

Selected Contents:

Statistical Processing of Results in Automated System of Radiation
Monitoring of Environment
(Zarkh & Ostroglyadov, Journal Article Abstract, 1 page)

Method of Assessing Combined Effect of Factors During Multiple Exposure of
Body

(Khvastunov, Journal Article Abstract, 1 page)

Effect of Night Watches and Intermittent Sleep on State of Circadian Rhythms
of Physiological Functions of Fishermen

(Skrupskiy, Journal Article Abstract, 1 page)

Neurophysiological Analysis of Hypothalamic Regulation Mechanisms of Primary
Sleep and Hypobiosis

(Karmanova, et al. Journal Article Abstract, 1 page)

Influence of General Vertical Vibration on Relationships Between Mediators
in Various Segments of Brain

(Dmitriyev, et al., Journal Article Abstract, 1 page)

JPRS REPORT
SCIENCE AND TECHNOLOGY
USSR: LIFE SCIENCES

JPRS-ULS-87-014

12 November 1987

Selected Contents:

Monitoring Brain Functional State

(Gazenko, et al., Newspaper Article Abstract, 1 page)

JPRS REPORT
SCIENCE AND TECHNOLOGY
USSR: LIFE SCIENCES

JPRS-ULS-88-002

26 February 1988

Selected Contents:

New Drug for Cardiovascular Disease

(Veysa, Journal Article Abstract, 1 page)

Synthesis and Investigation of Radioprotective Activity of N,N'-
Dipiperidonoalkyl Dihydrochlorides

(Yermakova, et al., Journal Article Abstract, 1 page)

Measuring Functional Feasibility of Human Visual System

(Shelepin, et al., Journal Article Abstract, 1 page)

Hypnosis -- Possible Applications for Cosmonauts

(Dmitruk, Journal Article Abstract, 1 page)



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16. Abstract <p>This is the sixteenth issue of NASA's USSR Space Life Sciences Digest. It contains abstracts of 57 papers published in Russian language periodicals or presented at conferences and of 2 new Soviet monographs. Selected abstracts are illustrated with figures and tables from the original. An additional feature is the review of a book concerned with metabolic response to the stress of space flight. The abstracts included in this issue have been identified as relevant to 33 areas of space biology and medicine. These areas are: adaptation, biological rhythms, bionics, biospherics, body fluids, botany, cardiovascular and respiratory systems, developmental biology, endocrinology, enzymology, exobiology, gastrointestinal system, genetics, gravitational biology, habitability and environmental effects, hematology, human performance, immunology, life support systems, man-machine systems, mathematical modeling, metabolism, microbiology, musculoskeletal system, neurophysiology, nutrition, operational medicine, perception, personnel selection, psychology, radiobiology, reproductive biology, and space biology.</p>					
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